Book 4

DMC

OPERATING and SERVICE MANUAL

model 8100/8100-W

FLUTTER METER

DATA MEASUREMENTS CORPORATION
855 COMMERCIAL STREET, PALO ALTO, CALIFORNIA, U.S.A. 94303

CERTIFICATION

DMC certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when shipped from the factory. DMC also certifies that its calibration measurements are traceable to the U. S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY

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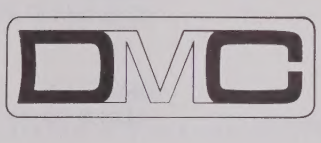

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FLUTTER METER

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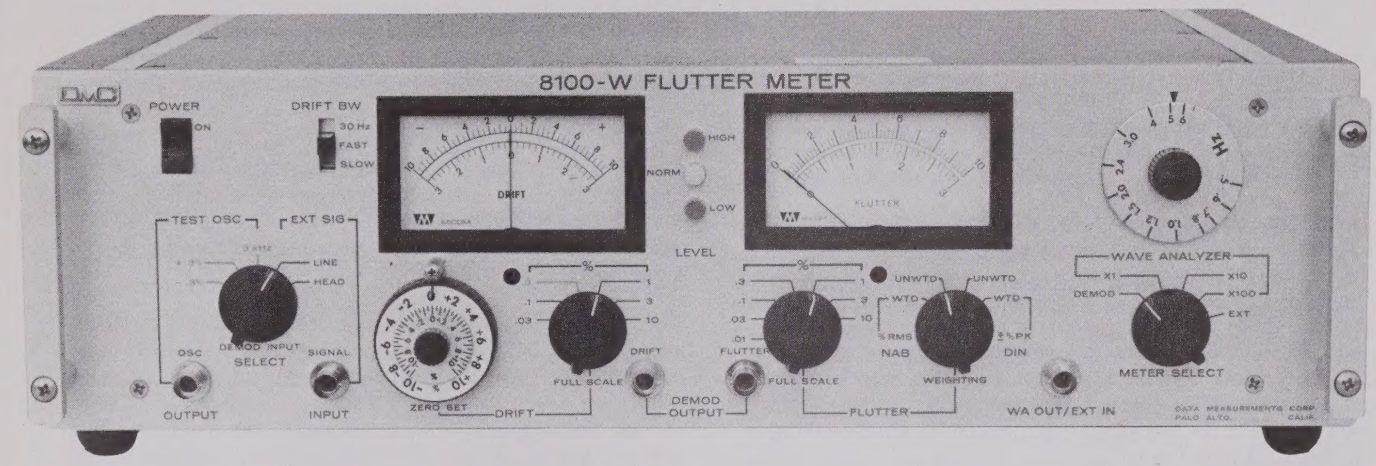


MODEL 8100/8100-W FLUTTER METER SPECIFICATIONS

TEST SIGNAL INPUT

Frequency: 3kHz ±10%
Input level ranges: 5mV to 200mV (HEAD sensitivity) and 100mV to 5V (LINE sensitivity) - AGC fully effective at 0.5mV input
Input Impedance: >300 kilohms, unbalanced, at 3kHz
AGC tolerability to drop outs: -20dB of less than 20 ms duration at 5mV input
Maximum acceptable frequency deviation: ±10%. (Range over which zero set may be adjusted to center drift meter)

SIGNAL FAILURE CLAMP

Restores meters to zero when signal is below range of best operation.
Not actuated by drop outs of less than 20 ms duration preceeded by input of 5mV or high on HEAD sensitivity position.
High Level Indicator: actuated by inputs exceeding allowable level.

DRIFT MEASUREMENTS

Frequency Range: DC to .7Hz ±20% (fast); DC to .2Hz ±20% (slow) at -3dB
Indication Mode: + or -% frequency deviation with "0" center meter
Test Ranges: ±.03, .1, .3, 1, 3, and 10% full scale
Meter Accuracy: ±5% full scale at DC

FLUTTER MEASUREMENTS

Frequency ranges:
.2 to 200Hz weighted to DIN Standard (±peak indication)
.5 to 200Hz weighted to NAB Standard (rms indication)
.3 to 200Hz at -3dB DIN unweighted (±peak indication)
.5 to 200Hz at -3dB NAB unweighted (rms indication)
Test ranges: .01, .03, .1, .3, 1, 3, and 10% full scale
Meter Accuracy: ±5% full scale at 40Hz unweighted, +1/2dB, -1dB from 1.5Hz to 150Hz, ±5% full scale at 4Hz weighted

INTERNAL TEST OSCILLATOR

Test Frequencies: f_o = 3kHz ±.1%
+.3% = f_o +9 ±.2Hz
-.3% = f_o -9 ±.2Hz
Output voltage: 1.23V rms ±10%
Source impedance: <100 ohms, unbalanced

DEMODULATOR OUTPUTS FOR ANALYSIS

DRIFT DEMODULATOR OUTPUT

Frequency Range: DC to 30Hz ±20% -3dB, falling at 18dB/octave above 60Hz. -3dB at .7Hz ±20% in slow and fast positions
Output Voltage: + or -.1V for full scale meter indication
Source Impedance: 1 kilohm unbalanced
Accuracy: ±2% true value at DC; +0, <-1dB from DC to 10Hz

FLUTTER DEMODULATOR OUTPUT

Frequency Range: .3Hz ±20% to 210Hz ±5% at -3dB, falling >6dB/octave below .3Hz and >20dB/octave above 220Hz
Output Voltage: .1V rms or ±.1V peak for full scale meter indication
Source Impedance: 1 kilohm unbalanced
Accuracy: ±2% true value at 40Hz; <+.2dB -.8dB from 1.5Hz to 150Hz

EQUIVALENT INTERNAL INSTRUMENT NOISE

<.0005% (with pure 3kHz sine wave input)

METER AMPLIFIER INPUT

Input Level: ±.1V peak or .1V rms for full scale meter indication
Input Impedance: 30 kilohm unbalanced

8100-W WAVE ANALYZER

Frequency Range: .5 to 600Hz continuously tunable in 3 decade bands
Accuracy of frequency calibration: ±5%
Frequency Response: Max. response ±1dB over entire tuning range
Bandwidth: 3dB down at ±5% of selected frequency, >20dB down at 1/2 and 2 times selected frequency
Indication: % rms or ±% peak on unweighted flutter indicator

GENERAL

Power: 115 or 230V, ±10%; 50/60Hz; 25 watts
Front Panel Dimensions: 5.25" x 19" wide
Cabinet Dimensions: 6.25" x 19" x 13" overall
Ambient temperature range: 0 - 60°C
Bench or Rack mount
Net Weight: 18 lbs.
Shipping Weight: 23 lbs.

SECTION I

GENERAL INFORMATION

1-1 DESCRIPTION

1-1.1 The MICOM 8100 and 8100-W Flutter Meters are solid state instruments for measuring and indicating long term variations (drift) and instantaneous variations (flutter) in speed of sound recording and reproduction equipment. Flutter is the audible effect in reproduced sound resulting from non-uniform motion in the mechanism. It is measured by recording and/or reproducing a constant frequency tone; the non-uniform motion frequency modulates the tone. This modulation, flutter, is measured with a special fm demodulator called a Flutter Meter.

1-1.2 The characteristics of the Flutter Meter, and the techniques for its use, are specified in the NAB (National Association of Broadcasters) standards and DIN (Deutche Industrie Normen) standards. The DIN standard has also been adopted by the International Radio Consultative Committee (CCIR).

1-1.3 The Models 8100 and 8100-W Flutter Meters have been developed not only to meet a real requirement for accuracy in the audio industry, but to make a contribution towards increased sophistication and precision in audio technology. These instruments now make possible an accuracy and sensitivity never before available. Foreseeable improvements in transports will not require better instrumentation.

1-1.4 Requiring no warm-up or calibration procedure before use, the Models 8100 and 8100-W are ideal for production line testing of audio apparatus. Their sensitivity and versatility make them indispensable research and development tools for a wide variety of instrumentation equipment, as well as preventive maintenance and quality assurance tools.

1-2 OPTIONS AVAILABLE

1-2.1 The MICOM 8100-W contains an integral wave analyzer tunable over a frequency range of from .5 Hz to 600 Hz in 3 decade ranges. (The Flutter Demodulator is limited to 200 Hz). When using the Wave Analyzer the Flutter indicator shows only the flutter components of the frequency tuned on the dial. The selectivity of the analyzer is approx. 0.1 octave, equivalent to that of an RLC tuned circuit with a Q of 10. With the aid of the frequency analyzer, and a knowledge of the mechanical design of the machine under test, specific parts of the mechanism contributing to the flutter may be determined.

1-2.2 BNC plug to Binding post adaptor: Pomona Electronics Model 1296. Permits the use of dual banana plugs on signal cables.

1-3 AUDIBLE EFFECTS OF FLUTTER

1-3.1 The ear senses fm as a changing frequency when the modulation is below 5 to 8 Hz; from nearly zero to about 1 Hz the pitch appears to "drift"; from about 1 Hz to about 5 to 8 Hz a "wow" is heard; above 50 to 200 Hz the ear hears the sidebands themselves as an added noise - "modulation noise". In the region between 8 to 50 Hz the tone quality is modified, causing a roughening of the tone, but the pitch change per se is not audible.

1-3.2 Frequency modulation is most audible when a sinusoidal tone is sinusoidally modulated, and the listener is in an acoustically "live" (reverberant) room. All other conditions reduce the audibility of fm: 1.) Musical instruments have fm and am (vibrato and tremulo) and beats (three-strings-per-note of a piano). 2.) An ensemble produces a complex sound, including beats (choral tone). This good musical quality obscures the effects of fm. 3.) Good sound recording and reproducing transports usually have a fairly random flutter waveform, less audible than sinusoidal fm. 4.) The limited duration of most musical tones limits the audibility of low frequency fm: the tone has ceased before the low frequency modulation has changed the tone's pitch very much. The fm threshold is lowered approximately ten times in a reverberant room with respect to headphone listening.

1-3.3 Threshold of flutter perception for 1 kHz tones sinusoidally modulated heard over earphones is about .1% peak for a 4 Hz modulation and approx. .25% peak for .5 to 50 Hz modulating frequencies. From above, the use of real music would raise the threshold, but listening in a room would lower it. Both DIN and NAB standards for professional recorders are set well above the threshold of perception, i.e., NAB .14% to .28% peak at 4 Hz; DIN, approx. .14% peak to .2% peak at 4 Hz.

1-4 SUMMARY OF FLUTTER MEASUREMENT TECHNIQUES

1-4.1 NAB MEASUREMENTS

1-4.2 Flutter is measured while reproducing an essentially flutter-free recording of 3 kHz.[1] Measurement shall be made at the beginning, middle and end of the reel used. The highest reading of the three positions measured shall be reported, excluding random peaks which do not occur more than three times in any 10-second period. Weighted and unweighted flutter shall be measured.

FLUTTER REQUIREMENTS BY NAB:

Speed ips	UNWTD FLUTTER % rms	WTD FLUTTER % rms
15	0.15	0.05
7-1/2	0.20	0.07
3-3/4	0.25	0.10

1 Not in NAB Standard: Suggested test tapes are Ampex Flutter Test Tapes 31316-01 (15 ips, 1/4 in tape), 31326-01 (7.5 ips, 1/4 in. tape), or 31336-01 (3.75 ips, 1/4 in. tape).

1-4.3 DIN MEASUREMENTS

1-4.4 a. Flutter: Flutter is measured by recording a test frequency, rewinding the tape, and reproducing this recording. Weighted flutter only is called for in the DIN measurement, and is designated as "±_____%" peak.

b. Drift: Two measurements may be made: i. Drift between the beginning and the end of the recording: A test tone is recorded at the beginning of a full tape pack; the drift meter is set for "zero". The resulting small tape pack is then placed on the supply turntable, and the larger one on the take-up, the tape is reproduced and the drift meter read. ii. Drift over a 30 second time interval: A recording is made, rewound, and reproduced. The difference between maximum and minimum drift meter reading is read over a 30 second interval.

FLUTTER AND DRIFT REQUIREMENTS BY DIN:

Speed ips	Classification	Flutter, +% Peak Weighted	Drift over 30 seconds ±%
30	Studio	0.10	0.2
15	Studio	0.10	0.2
7-1/2	Studio	0.15	0.2
7-1/2	Home	0.20	2.0
3-3/4	Home	0.30	2.0
1-7/9	Home	0.60	2.0
15/16	Home	1.0	2.0

Drift, beginning/end: Maximum value not specified for any case, above.

1-4.5 CCIR MEASUREMENTS

1-4.6 The CCIR recommendation allows the measurement of peak value or rms value, weighted and unweighted. If the peak value is measured, the instrument response to pulse tests is prescribed. When reporting flutter measurements, indication should always be given as to whether peak, rms, weighted, or unweighted values were measured. Although not mentioned in the CCIR recommendation, it is also essential to report whether an essentially flutter-free test tape was used, or whether the test signal was recorded and then played back on the same instrument.

1-4.7 RELATIVE SPEED MEASUREMENTS

1-4.8 The exact measure of speed of a transport by means of a test tape is not possible. Even assuming a constant wavelength originally recorded on the tape, such a constant wavelength will not be maintained due to the elastic properties of the tape. The reproduced frequency will be affected not only by the capstan speed, but also by variations in tension, previous stresses of the tape, temperature, as well as the surface properties of the tape. In addition, the transport speed is controlled by the instantaneous power line frequency. Peak to peak deviations of line frequency of up to .1% within a few minutes interval are quite common. However, very accurate comparative speed measurements may be made with the MICOM 8100 or 8100-W Flutter Meter, particularly measurements of variations in speed between one diameter reel of tape and another. If the transports used for recording and reproducing have nearly the same tape tension and if both are driven by the same line frequency (for example, a standard 60 Hz supply), then comparative speed measurements to better than 0.1% accuracy may be expected.

1-5 COMPARISON OF NAB AND DIN MEASUREMENTS

1-5.1 Although numerous tests have shown that measurements made by either method provide equally valid results, several considerations must be kept in mind when comparing the values indicated by each method.

When an essentially flutter-free test tape is used in an NAB measurement, what is indicated is the average value of the flutter waveform, with the meter calibrated to indicate the rms value of a sinewave of that average. The dynamic response of the meter allows it to follow the envelope of changing levels up to several Hz.

In using the DIN method, when the test signal is recorded, flutter is introduced in the wavelength of the recorded signal on the tape; when this tape is played back, the flutter during recording is added to the flutter of the instrument during playback. In general, the flutter measured with this method will be higher than that measured by reproducing a low-flutter test tape. However, when the flutter content is largely sinusoidal at a low frequency (as is very common), cancellation of the reproduced flutter by corresponding variations in wavelength on the recorded signal may occur. Variations ranging from twice the peak value of flutter to almost complete cancellation are possible.

Causing random slipping of the tape during playback will reveal any cancellation if the flutter level changes drastically after such disturbance.

When reproducing essentially flutter-free test tapes, flutter dominated by a single sinusoidal component will be 1.4 times higher on a ± peak meter than an rms calibrated meter will indicate. Typically, measurements made on the same transport will indicate from 1.5 to 3.0 times higher flutter using the DIN method than will be measured with the NAB method.

1-6 WEIGHTED VERSUS UNWEIGHTED MEASUREMENTS

1-6.1 There is sometimes controversy as to whether weighted measurements or unweighted measurements are better measurements of tape recorder performance. Naturally, a wide-band measurement will always result in a higher indication than will a weighted measurement. However, extensive tests have shown that the same amount of flutter at from 2 to 10 Hz is much more objectionable to a listener than flutter at a 100 to 200 Hz range.

The flutter weighting function is designed to permit a single measurement that correlates with subjective listening tests. Unweighted measurements are particularly useful with professional equipment when overall quality of sound reproduction is paramount. Note that all standards for professional transports require a lower weighted flutter than unweighted. Neither measurement will reveal all the flutter; all transports exhibit an important flutter content in the 3 to 10 kHz range: so-called "scrape flutter," which can only be measured with a wide-band flutter meter such as the MICOM Model 8200.

1-7 NAB STANDARD - Magnetic Tape Recording and Reproducing (Reel-to-Reel). April 1965* (Applicable Paragraphs):

2.12 It shall be standard that in the reproduce mode the unweighted flutter content when reproducing an essentially flutter-free recording of 3 kc at any portion of the reel of tape in use shall not exceed the following:

Tape Speed	Flutter (rms)
15 ips	0.15%
7-1/2 ips	0.20%
3-3/4 ips	0.25%

2.12.01 Unweighted flutter content shall be measured over the frequency range of 0.5 cps to 200 cps. The response of the measuring system shall be 3 db down at 0.5 cps and 200 cps, and falling at a rate of at least 6 db per octave below and above these frequencies, respectively. At low frequencies where the meter pointer follows the wave form, the maximum deflection shall indicate the rms value. The indicating meter shall have the dynamics of the Standard Volume Indicator (ASA C16.5-1961), a full-wave rectified average measurement law, and shall be calibrated to read the rms value of a sinusoidal frequency variation.

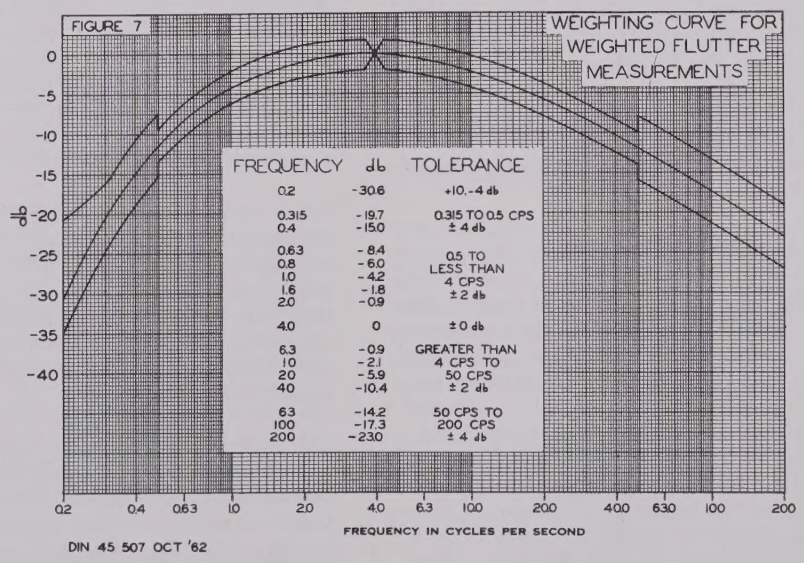
2.12.02 It shall be standard that the meter be read for random periods throughout the length of the tape, noting the average of the peak readings, but excluding random peaks which do not recur more than three times in any 10-second period.

2.13 It shall be standard that in the reproduce mode the weighted flutter content when reproducing an essentially flutter-free recording of 3 kc at any portion of the reel of tape in use shall not exceed the following:[17]

Tape Speed	Flutter (rms)
15 ips	0.05%
7-1/2 ips	0.07%
3-3/4 ips	0.10%

2.13.01 Weighted flutter shall be measured over the frequency range of 0.5 to 200 cps. The response of the measuring system shall be as specified in Figure 7. At low frequencies where the pointer follows the wave form, the maximum deflection shall indicate the rms value. The indicating meter shall have the dynamics of the Standard Volume Indicator (ASA C16.5-1961), a full-wave rectified average measurement law, and shall be calibrated to read the rms value of a sinusoidal frequency variation.

2.13.02 It shall be standard that the meter be read for random periods throughout the length of the tape, noting the average of the peak readings, but excluding random peaks which do not recur more than three times in any 10-second period.



[17] The weighted flutter measurement employs a frequency response similar to the sensitivity of the ear to frequency variations versus the frequency of these variations ("flutter rate") and is intended to give a more useful indication of the subjective effect of flutter than the unweighted measurement.

* Obtainable from: Engineering Dept., National Association of Broadcasters, 1771 N Street, N. W., Washington, D. C.

1-8 DIN STANDARD (DIN 45-507, October 1966*)

MEASURING EQUIPMENT FOR FREQUENCY VARIATIONS ("FLUTTER" AND "DRIFT") IN SOUND RECORDING EQUIPMENT

1. GENERAL

This measuring equipment for frequency variations ("flutter" and "drift") serves to measure speed variations of the medium in sound recording equipment. To this end, a test frequency is recorded, and its variation during reproduction is measured.

2. TEST FREQUENCY

The nominal frequency for the test signal is 3.15 kHz.[1] The measuring equipment must also perform within the following specifications when the test frequency differs from the nominal value by ±3%.

3. FREQUENCY RESPONSE

3.1 The frequency variations ("flutter") read from the measuring equipment should be reported as a single value; very low frequency variations are not included since they are measured separately as drift. The measurement is to be performed using a weighting curve (see Figure 7, under Section 1-7 of this manual). The weighting factors are also shown in this table. The weighting curve must not rise again outside the frequency range of 0.2 to 200 Hz.

3.2 The range from 0 to 0.2 Hz ("drift") shall be indicated in a separate measurement. Both the direction and the amplitude of the deviation shall be indicated in this measurement.

Another method (the "beat frequency method") may be used, with a test frequency other than 3.15 kHz. A known frequency is recorded, and the reproduced frequency is compared with it. If the line frequency is used with equipment powered by the line, the effect of line frequency variations is eliminated.

3.3 In addition to the standard weighted measurement described above, it is desirable that the measuring equipment also be able to make unweighted measurements up to fairly high variation frequencies, in order to be able to make frequency analyses, for instance. For the measurement of frequency intermodulation (due to vertical tracking errors in stereo phonograph pickups) according to DIN 45 542 (still in draft form), a fairly uniform frequency response up to 300 Hz is necessary. The frequency response of the measuring equipment should be specified. The requirements of Section 4.1 ("peak indication") need not be fulfilled with an unweighted measurement.

4. PEAK INDICATION

4.1 The measuring equipment shall indicate the quasi-peak value according to the following specifications:

The indication shall be tested with rectangular pulses of a frequency deviation occurring in one direction only, with a repetition rate of one pulse per second; the following values shall be obtained:

Pulse length, ms	10	30	60	100
Indication, %	21 ±3	62 ±6	90 ±6	100 ±4

The reading from a sinusoidal frequency modulation at 4 Hz, having the same peak-to-peak frequency deviation, is defined as 100%; that is, $\Delta f_{pulse} = 2\,\Delta f_{sin\ max}$ (see Figure 2). The fall time shall be measured with a pulse length of 100 ms using a repetition rate of one pulse per second. Between the pulses, the indication shall fall to 41 ±4% of the maximum reading.

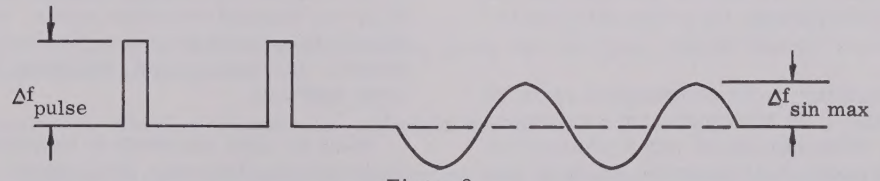


Figure 2

These measurements shall be performed with the weighting filter in the circuit. The instrument shall read positive as well as negative deviations, as would be obtained, for example, by using a voltage doubler.

Because of the finite fall time, it is impossible to avoid variations in the reading with frequency variations of very low frequency. In this case, the maximum value should be read.

---

* Translated by Erling Skov and J. G. McKnight, Ampex Corporation; March, 1963, revised June, 1967.

1 This test frequency and the frequencies in the graph are preferred frequencies for acoustical measurements, in accordance with DIN 45 401 and ISO Recommendation R266.

4.2 The instrument shall be calibrated in terms of a sinusoidal frequency modulation. The scale shall indicate +...% (or per mil, °/oo) frequency variation ("flutter") which is one half the peak-to-peak value.

4.3 The properties defined in Sections 4.1 and 4.2 must obtain for all sensitivity ranges.

5. RANGE OF INDICATION
The equipment shall have a range with a full scale reading obtained from a frequency variation not to exceed ±0.15%, and other ranges indicating full scale for a frequency variation not less than ±5%.

6. OVERLOAD PERFORMANCE
Even in the least sensitive range, the indication for frequencies between 0.8 and 20 Hz must be linear up to full scale (see Section 7). An overload indication is desirable.

7. INDICATION ERRORS
When measuring under steady-state conditions, the indication error must not exceed ±10% of the full scale value. The errors must not increase to more than 15% for any of the conditions shown in (a) to (f).

(a) Input voltage deviation of ±6 dB during the measurement.

(b) Thirty percent rectangular amplitude modulation of the input voltage at a frequency of 4 Hz at a reading of 0.15% frequency variation.

(c) Frequencies up to 180 Hz (for example, hum) contributing up to 20% rms in the input voltage.

(d) Line voltage deviations of ±10%.

(e) Room temperatures between 15 and 35°C (60 and 95°F), measured after a warm-up time of 15 minutes.

(f) External 50 (or 60) Hz field of 4 amperes/meter (approximately 50 m0e). (For a method of measuring the ac magnetic field, see DIN 45 410.)

8. INPUT VOLTAGE REQUIREMENT
The required input voltage shall not exceed 100mV. An indication of the correct level is desirable.

9. INPUT IMPEDANCE
The input impedance shall not be less than 300 kilohms at 3.15 kHz.

10. AUXILIARY FEATURES
It is desirable to be able to connect external filters of other analyzing equipment, for example, an oscillograph. (Approximately 1V output should be provided for a full-scale reading.)

1-8.1 EXPLANATORY COMMENTS ON DIN 45 507*

In sound recording it is impossible to obtain completely constant speed of the recording medium because of the limited mechanical drive. It is impossible to avoid short-time deviations ("flutter") and there is also often a difference between the average speed at the beginning and at the end of the recording ("drift").

For a constant frequency, f, the wavelength λ varies in recording proportionally to the transport speed according to the equation $\lambda = v/f$. When reproduced with a perfect drive (v = constant), the frequency which was so recorded will show a corresponding frequency modulation. In practice, however, the reproducing system adds its own speed variations, and the consequent frequency modulation adds vectorially to that from the recording. The transport speed variations are best measured by recording a test frequency, and then measuring the frequency deviations in the subsequent reproduction.

1. Measuring short-time deviations ("flutter").

When no recording or reproducing transport is available with speed variations much smaller than those of the transport under test, recording and reproduction is usually done on the transport under test. Therefore, a vectorial addition of the two identical deviations occurs, and the resulting deviations depend upon the phase relation between the two components. In extreme cases, the result is very nearly arithmetic addition.

Since the ear's sensitivity to frequency deviations depends on the deviation frequency, the measurements are performed with a weighting filter which approximates the characteristics of the ear.

A satisfactory approximation is possible only at the relatively low variation frequencies. At frequencies above approximately 100 cps, the disturbing effect depends mostly on the frequency and the level of the recorded tones. This disturbance can be quite sizable under certain conditions. In order to obtain readings that are at least comparable, the weighting curve was defined up to 200 cps. If, in special cases, large variations appear at higher frequencies (for example, the longitudinal tape vibrations known as "scrape flutter") special measuring procedures are necessary.

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*For explanatory comments on the proposal for this standard see Elektronorm (vom FNE im Deutschen Normensausschuss) 15, pp. 88-89 (Mar., 1961).

The fact that the deviations are normally not sinusoidal makes it necessary also to specify the properties of the rectifier circuit and the indicating instrument.

In some other countries the rms value of the deviation is measured. Since different weighting curves, or none at all, are used in those countries, the results cannot be compared directly.

2. Measuring long-time deviations ("drift" between the beginning and the end of the recording).

This measurement is of particular importance when a non-synchronous (e.g. friction) drive is used, as for example with tapes without perforations. Tapes are often edited after recording, so that the location of a section of the tape within the tape pack is changed. When drift occurs, sections of tape which have been recorded with somewhat different speeds may be edited together. In this case, a sudden change in pitch will occur in reproduction, which can be especially disturbing in music recordings. In order to measure the drift, a test tone is recorded at the beginning of a full tape pack. The resulting small tape pack is then placed on the supply turntable, and the larger one on the take-up. If there is drift, reproduction under these conditions results in the frequency deviating from the originally recorded frequency. The relative frequency difference is called "drift."

In disc and film recording, test records and films of sufficient accuracy are available, so that the drift can be measured directly.

The frequency deviations are normally measured by means of a frequency discriminator. If the coupling network following the discriminator does not pass d.c., this method cannot be used for drift measurement.

In this case, the drift may be measured by counting the beats between the reproduced frequency and the frequency from the generator which was used in recording. When testing disc equipment, the frequency obtained from the inner grooves is compared with the frequency from a generator which has been adjusted to the frequency obtained from outer grooves.

One variation of this method of drift measurement which may be used with tape machines is to record the line frequency, and after exchange of tape packs, compare the reproduced frequency with the line frequency. This has the advantage in transports driven from the line that the errors due to variations of line frequency are canceled out.

3. Measuring the absolute speed.

When a positive drive is used, it is possible to measure the absolute speed of the medium by reproducing a recording of the exact test frequency and comparing the reproduced frequency with a standard frequency of 3.15 kc. It does not seem reasonable to demand the necessary frequency accuracy and stability of the frequency variation meter itself.

The exact measurement of the speed of a non-perforated tape is impossible. The use of a test tape for such a speed measurement is not feasible because the reproducing speed depends, due to the differing tape tensions, on the elastic properties of the particular tape; and also depends, due to the complicated rolling process between the capstan and the pressure roller, on the tape's surface properties.

1-9 CCIR STANDARD (Recommendation 409-1, 1966)

MEASUREMENT OF WOW AND FLUTTER IN RECORDING EQUIPMENT AND IN SOUND REPRODUCTION

The CCIR unanimously recommends:

1. That two methods, one giving the peak value and the other giving the rms value, may be used for the measurement of wow and flutter in sound-recording equipment.

2. That these measurements should, preferably, be performed at a frequency of 3000 Hz.

3. That the measurements made, with or without the appropriate weighting, should include all flutter and wow frequencies in the range 0.2 Hz to at least 200 Hz.

4. That indications should always be given as to whether the peak or the rms value was measured, and if the weighting network was, or was not, in use.

5. That, when measuring the peak value, the measuring equipment should have the following specifications:

   5.1 Frequency of measurement: 3000 Hz (a frequency of 3150 Hz, corresponding to ISO Recommendation R266, 1962, could also be used).

   5.2 Response curve: As specified in Table 1 and Figure 1 (see Figure 7, in Section 1-7 of this manual), giving a value which corresponds closely to the subjective impression (an additional response curve, "flat" at least between 0.2 and 200 Hz would provide useful information about sources of wow and flutter. Tolerances and dynamic characteristics are not specified for the "flat" curve).

5.3 Dynamic characteristics (with weighting): For short unidirectional deviations of the frequency of measurement (rectangular pulses of a duration A) with a repetition rate of 1 Hz, the meter should indicate the percentage B of the reading obtained with a sinusoidal frequency-modulation of 4 Hz having a peak-to-peak deviation equal to the frequency swing of the pulse.

A - Duration of impulse (ms)	10	30	60	>100
B - Indication (%)	21 ±3	62 ±6	90 ±6	100 ±4

The return time should be such that, when applying pulses of 100 ms duration with a repetition rate of 1 Hz, the meter should indicate (40 ±10)% between the pulses.

5.4 Indication: The meter should measure peak-to-peak values, but the reading should indicate the wow in per cent or in parts per thousand of the figure corresponding to one half the peak-to-peak value.

NOTE: For the measurement of the rms value, further technical specifications, as necessary for comparable results, are under discussion.*

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* In Japan, the following technical specifications are applied when measuring rms values:

- Measurement frequency: 3000 Hz
- Response curve: Same as specified in Paragraph 5.2
- Characteristics of rectifier: Square-law type with an exponent of 2 ±0.1
- Dynamic characteristics: For unidirectional pulses with Duration A, the meter should indicate the following percentage B of the reading obtained with a 5s pulse:

A - Duration of pulse (s)	0.5	1	2	5
B - Indication (%)	36 ± 5	78 ± 5	83 ± 5	100 ± 5

SECTION II

INSTALLATION

2-1 INSPECTION

2-1.1 This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also check for supplied accessories, and test the electrical performance of the instrument. If there is damage or deficiency, see the warranty in Section 1.

2-1.2 CLAIM FOR DAMAGE IN SHIPMENT

2-1.3 Your instrument should be inspected and tested as soon as it is received. The instrument is insured for safe delivery. If the instrument is damaged in any way or fails to operate properly, file a claim with the carrier or, if insured separately, with the insurance company.

2-2 POWER REQUIREMENTS

2-2.1 The Models 8100 and 8100-W will operate from either 115 or 230V ac 50 - 60 Hz. The instruments can be easily converted from 115 to 230 volt operation by changing the position of the slide switch, located on rear panel, so that the designation appearing on the switch matches the nominal voltage of the power source. A 1/2 ampere, slow-blow fuse is used for 115-volt operation; a 1/4 ampere slow-blow fuse is used for 230-volt operation.

2-3 THREE CONDUCTOR POWER CABLE

2-3.1 To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. All MICOM instruments are equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground wire.

2-3.2 To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong adapter to ground.

2-4 INSTALLATION

2-4.1 The 8100 and 8100-W are fully transistorized; therefore, no special cooling is required. However, the instruments should not be operated where the ambient temperature exceeds 65°C (150°F).

2-5 RACK/BENCH INSTALLATION

2-5.1 The 8100 and 8100-W are shipped as bench type instruments with rubber feet. To mount the instrument in a standard 19" relay rack, remove the side castings. Two 10-32 screws in each handle and one side mounting screw to the rear attach each casting to the instrument. Use the screws in the handles to fasten the instrument in a rack.

2-6 REPACKAGING FOR SHIPMENT

2-6.1 The following is a general guide for repackaging for shipment. If you have any questions, contact the factory.

a. Place instrument in original container if available. If original container is not used,

b. Wrap instrument in heavy paper or plastic before placing in an inner container.

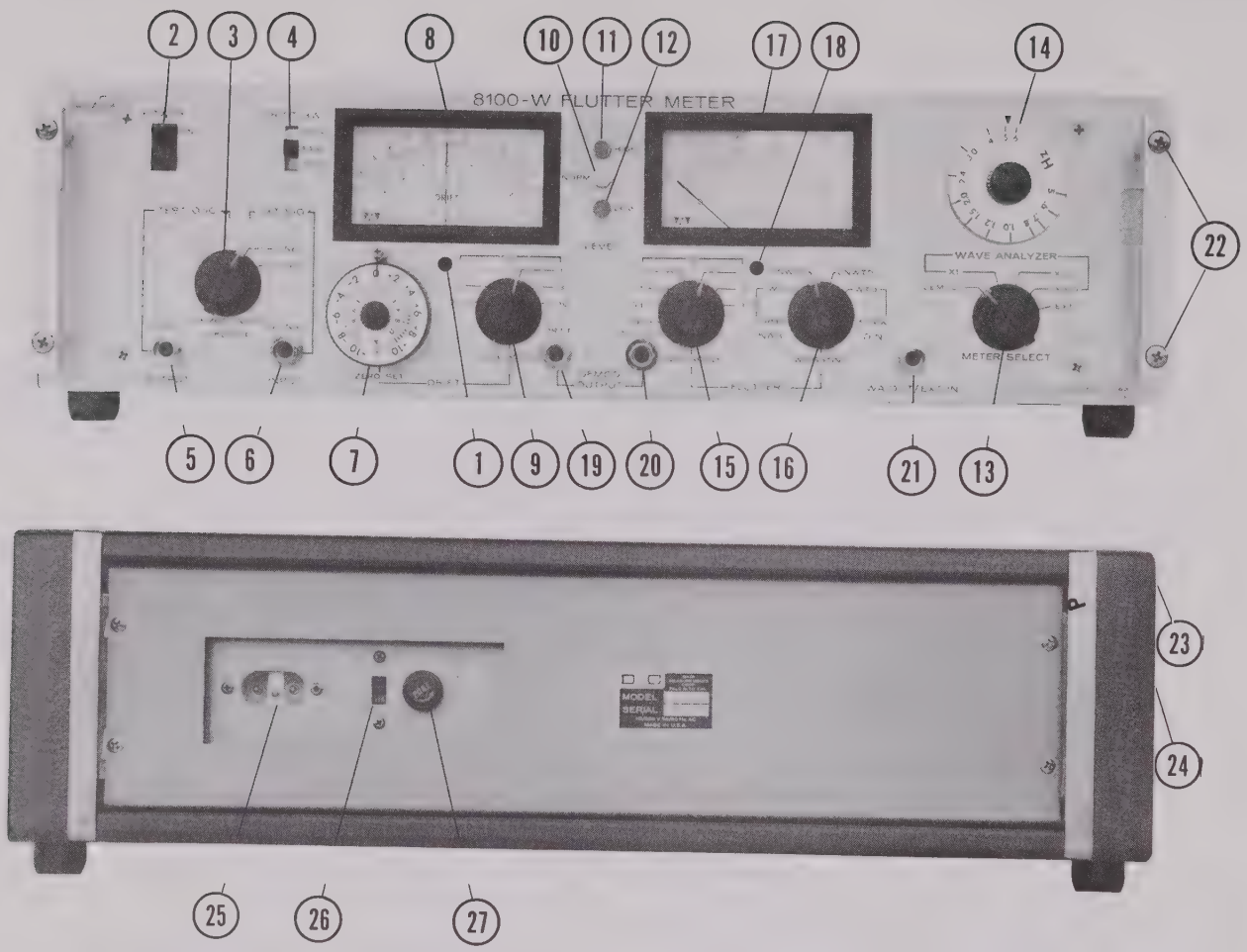
c. Use plenty of packing material around all sides of instrument and protect panel faces with cardboard strips.

d. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

e. Mark shipping container with "Delicate Instrument", "Fragile", etc.

NOTE

If the instrument is to be shipped to MICOM for service or for repair, attach a tag to the instrument identifying the owner and indicate the service or repair to be accomplished; include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model and serial number.



1. MECHANICAL ZERO ADJUST mechanically sets zero of meter prior to turning instrument on.
2. POWER switch turns instrument ac power on. HIGH, NORMAL, or LOW level lamp will glow when instrument is on.
3. DEMOD INPUT SELECT selects input to instrument. CCW positions control frequency of test oscillator and connects oscillator to input. CW positions select input level HEAD (5 - 200mV) or LINE (1 V to 5 V).
4. DRIFT BW selects high frequency cutoff of DRIFT DEMOD output at 30 Hz or .7 Hz. FAST position allows .7 Hz meter response. SLOW position allows .2 Hz meter response.
5. TEST OSC OUTPUT connector permits recording output of test oscillator.
6. SIGNAL INPUT connector permits recording output of test oscillator.
7. ZERO SET controls the frequency at which the drift meter indicates zero. Outer dial changes frequency in 2% increments, inner vernier adjusts over ± 1.1% range.
8. DRIFT METER indicates percentage of frequency difference between input signal and ZERO SET control.
9. DRIFT RANGE SELECTOR switch sets sensitivity of drift indicator from ± .03% F.S. to ± 10% F.S.
10. NORMAL INPUT LEVEL lamp glows to indicate that the input level is within the range of normal operation.
11. HIGH INPUT LEVEL lamp glows to indicate that the input level is too high for proper operation.
12. LOW INPUT LEVEL lamp glows to indicate that the input level is below that required for proper operation.
13. METER SELECT selects the source of signal into the meter driver amplifier, either from the Flutter Demodulator or External. (On Model 8100-W, also selects wave analyzer frequency multiplier and allows meter to indicate Wave Analyzer output.)
14. FREQUENCY dial (Model 8100-W only) selects frequency of response of Wave Analyzer.
15. FLUTTER RANGE SELECTOR switch sets the sensitivity of the flutter demodulator amplifier from .01% to 10% F.S.
16. METER WEIGHTING SWITCH selects the type of flutter indication as RMS weighted or unweighted (meter with dynamics of standard VU meter) or ± peak weighted or unweighted.
17. FLUTTER INDICATOR meter indicates percentage of flutter contained in the input signal, or the amplitude of the EXTERNAL INPUT signal.
18. MECHANICAL ZERO ADJUST mechanically adjusts Flutter indicator to read zero when the instrument is turned on and the METER SELECT switch is in EXT INPUT position.
19. DRIFT DEMOD OUTPUT connector provides a means of monitoring the output of the meter circuit with an oscillograph, oscilloscope, or voltmeter.
20. FLUTTER DEMOD OUTPUT connector provides a means of monitoring the output of the flutter amplifier with an oscilloscope, oscillograph, voltmeter, or wave analyzer.
21. EXTERNAL INPUT connector provides input connection for external signals to Flutter Meter driver. On 8100-W permits monitoring wave analyzer output.
22. MOUNTING SCREWS in handles permit removing side plates for rack mounting.
23. SIDE PLATES convert instrument from rack mount to bench instrument, have attached rubber feet.
24. SIDE MOUNTING SCREW holds side plate to instrument.
25. AC POWER CONNECTOR provides input connections for ac power.
26. LINE VOLTAGE (115V/230V) switch sets instrument to operate from 115 V ac.
27. FUSE provides protection for line and instrument circuits.

NORMAL CONTROL POSITIONS SHOWN BY RED ENGRAVING

SECTION III

OPERATING INSTRUCTIONS

3-1 INTRODUCTION

3-1.1 The Models 8100 and 8100-W Flutter Meters will measure both reproduced frequency error and flutter in tape recorders. Drift in speed with rates to .2 Hz is indicated on the Drift meter. Drift of from ±.03% to ±10% full scale may be accommodated. Flutter content of recorder output over the frequency range of .3 Hz to 200 Hz is indicated on the Flutter meter, with a full scale range of from .01% to 10%. The drift meter may be centered for any steady speed error of up to ±10% by means of the Zero Set control. This control has a vernier resolution of <.002%, although the absolute accuracy is only approx. ±.1% near zero and may be only ±.5% at either extreme of ±10%.

3-1.2 Input levels of from 5 mV to 5 V may be accommodated. Level indicator lamps automatically indicate when the input is within the range for proper operation. A fast AGC signal amplifier accommodates momentary dropouts of up to 20 dB. Whenever the input falls below the level required to allow 20 dB dropouts without degradation of accuracy the low level indicator glows and the demodulator outputs are clamped to prevent pinning the meters. Excessive levels cause a high signal indicator to glow.

3-2 CONTROLS AND INDICATORS

3-2.1 Figure 3-1 illustrates and describes the function of all front and rear panel controls, connectors, and indicators. Normal positions are marked in RED on the instrument.

3-3 OPERATING INFORMATION

3-3.1 A signal input of 3 kHz ±10% should be connected to the SIGNAL INPUT BNC connector through a shielded cable. If desired, a twin banana plug-to-BNC adaptor (Pomona 1296) may be used.

3-3.2 The DIN method requires making a recording, rewinding the tape, and measuring the flutter while reproducing this recording. For this purpose the MICOM 8100 and 8100-W Flutter Meters have a test oscillator. High quality tape should be used for test recording and it MUST BE BULK ERASED BEFORE EACH USE. The oscillator is not used in the NAB method. The NAB method requires reproducing an essentially flutter-free tape with the transport under test. Suitable test tapes are AMPEX FLUTTER TEST TAPES 31316-01 (15 ips 1/4" tape), 31326-01 (7.5 ips 1/4" tape), or 31336-01 (3.75 ips 1/4" tape).

3-3.3 If the output from the transport under test is between 5 mV and 200 mV, the DEMOD INPUT SELECT switch should be turned full clockwise to HEAD position. This position is used for signals from the tape reproducer head with no preamplifier. There is no advantage in using a separate tape preamplifier; in fact, if the system being tested is not fully checked out as a reproducer, it is preferable to use the HEAD input sensitivity position of the Flutter Meter. Line level inputs between 100 mV and 5 V are accommodated by the LINE position of the DEMOD INPUT SELECT switch.

3-3.4 For either input, the LEVEL indicator lamps show LOW, NORMAL, or HIGH input level. Since the signal amplifier contains an AGC with approx. 40 dB dynamic range, the NORMAL lamp will glow when the INPUT SELECTOR switch is in the proper position and the input adequate for full accuracy. During rewind, the high frequency signal obtained from a head may defeat the signal failure circuit. The Flutter Meter INPUT SELECT switch should therefore be switched to the 3 kHz position during rewind.

3-3.5 The ZERO SET control is used to set the frequency at which the DRIFT METER is centered. The meter may be zeroed for any frequency ±10% of 3 kHz. When transports are operated at other than 60 Hz line frequency, or with components such as belts of improper thickness, and therefore have a large constant speed error, sensitive drift measurements may be made by using the ZERO SET control to center the drift meter. This concentric control changes the zero approximately 2% for each major division. The vernier covers a range of ±1.1% and has a resolution of better than .002%. When the DRIFT meter is centered (within 1 or 2%) by the ZERO SET control, the Drift and Flutter indications are accurately made in percent of the actual input frequency.

3-3.6 The DRIFT SENSITIVITY switch allows from ±.03% to ±10% drift to deflect the DRIFT meter full scale.

3-3.7 CAUTION - When measuring small drift in the presence of large flutter the DRIFT BW switch must be in either the FAST or SLOW position. When in the 30 Hz position, the drift amplifier bandwidth is 30 ±20% Hz. The meter cannot respond to frequencies above approx. 1 Hz, and if the drift amplifier has full bandwidth, large flutter will cause the amplifier to saturate on the sensitive ranges. Accuracy and sensitivity of the meter will be reduced if the amplifier saturates. Always leave the DRIFT BW switch in the FAST (0.7 Hz BW) or SLOW (0.2 Hz BW) positions except when using the DRIFT DEMOD output.

3-3.8 The FLUTTER SENSITIVITY switch permits indications of flutter of .01% full scale to 10% full scale. The instrument noise is so low that accurate measurements are possible even on the .01% full scale range. With a noise-free input signal, the total instrument noise and residual carrier will be less than .0005% rms (5ppm) at the output of the demodulator.

3-3.9 The WEIGHTING switch selects the mode of indication of the FLUTTER meter. In the NAB WTD position the meter

indicates flutter as % rms, with the flutter frequency content weighted in accordance with the curve of Fig. 7, Sec. I. NAB UNWTD position provides a flat response to flutter components from .5 Hz to 200 Hz and indicates as % rms. In both NAB positions the meter has a VU dynamic response to complex waveforms. A DIN flutter measurement is by definition a weighted measurement. The DIN WTD position causes the meter to indicate ±% peak flutter components with the frequency weighting of Fig. 7, Sec. I. The DIN UNWTD position causes the FLUTTER meter to indicate ±% peak flutter components within the frequency range of .2 Hz to 200 Hz. The transient response of the meter in both DIN positions conforms to DIN specification 45 507 of October 1962 (see Page 1-5, Par. 4).

3-3.10 The METER SELECT switch permits the meter to either indicate the FLUTTER DEMOD output, or to indicate the amplitude of an EXTERNAL INPUT. An EXTERNAL INPUT of 0.1 V rms results in full scale Meter indication with the WEIGHTING switch in the NAB UNWTD position. ±0.1 peak (0.2 V peak-to-peak) results in full scale indication with the WEIGHTING switch in the DIN UNWTD position.

3-3.11 WAVE ANALYZER (Model 8100-W) frequency multiplier selection is accomplished with the METER SELECT switch. The frequency indicated on the tuning dial may be multiplied x 1, x 10, or x 100. When the METER SELECT switch is on any multiplier position the FLUTTER meter automatically indicates the amplitude of the component of flutter tuned by the wave analyzer. When in the wave analyzer positions, the output of the analyzer appears at the EXT INPUT terminal.

3-3.12 External signals to the METER AMPLIFIER INPUT BNC connector are indicated on the meter when the METER SELECT switch is in the EXTERNAL position. 100 mV rms causes the meter to read full scale when the WEIGHTING switch is in the NAB positions, and ±100 mV peak causes the meter to read full scale when the WEIGHTING switch is in the DIN positions.

3-3.13 The DRIFT DEMOD OUTPUT BNC connector provides an output of ±100 mV when the meter reads full scale. This output has a bandwidth of from DC to 30 Hz ±10% when the rear panel DRIFT BANDWIDTH switch is in the 30 Hz position. Its source impedance is 1 kilohm. This signal is particularly useful when recorded by an oscilloscope or an oscillograph in analyzing the transient response of a reproducer when starting, stopping, or when subjected to large disturbances. The DRIFT DEMOD bandwidth is .2 Hz ±20% when the rear switch is in the .2 Hz position.

3-3.14 The FLUTTER DEMOD OUTPUT BNC connector provides an output of 100 mV rms or ±100 mV peak when the FLUTTER meter reads full scale on the NAB or DIN positions respectively. The source impedance is 1 kilohm. This output is particularly useful for oscilloscope observation to gain better knowledge of the full characteristics of the flutter. The FLUTTER DEMOD output may be passed through external filters to the EXTERNAL INPUT BNC connector for measurements of flutter at bandwidths other than 0.5 to 200 Hz. The input impedance of the Meter amplifier is 30 kilohms at the EXTERNAL INPUT connector.

3-3.15 The DIN Standard requires recording a constant frequency with the machine under test and reproducing as in 3-3.16. The TEST OSCILLATOR permits testing in conformance with European practice. The DIN Standard recommends 3150 Hz; however the 3 kHz supplied by the MICOM 8100/8100-W is acceptable, and conforms to CCIR recommendations.

3-3.16 The TEST OSCILLATOR OUTPUT BNC connector provides a 3 kHz ±.1%, 1.23 V signal from a 100 ohm source. This signal is very useful in testing transports with exceptionally low flutter or drift. Presently available test tapes have some flutter content and may have from .2% to ≈.5% error in recorded wavelength. Current Ampex tapes when new, have a flutter content of from .015 to .03% NAB unweighted. If the system has lower flutter than the available test tape (or if a test tape is not available), the TEST

MICOM MODEL 8100/8100-W

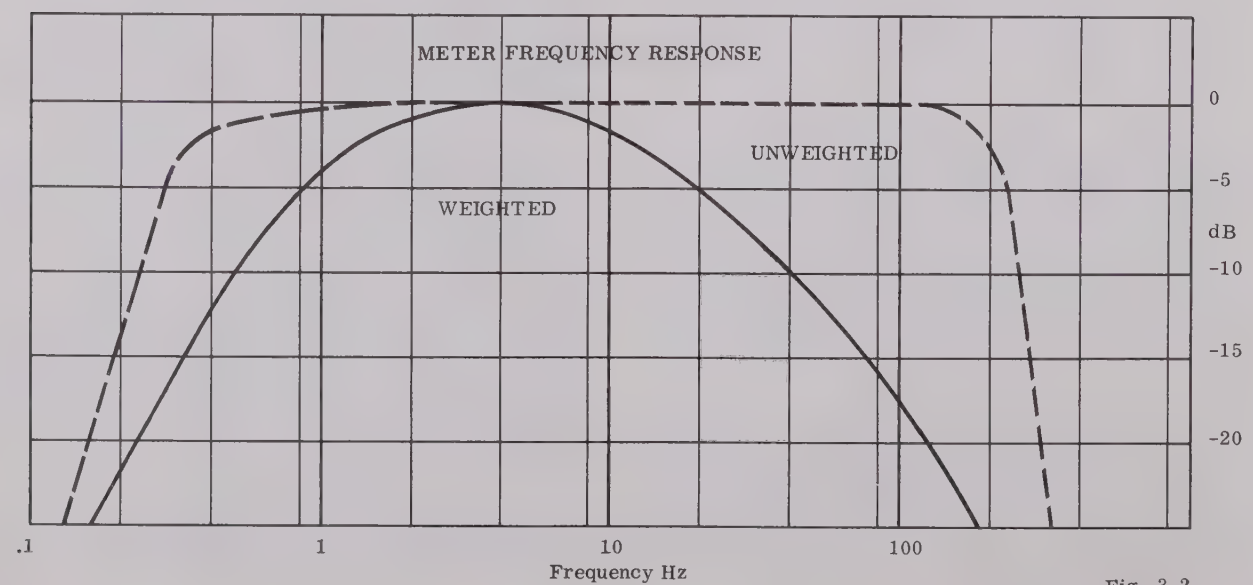


Fig. 3-2

OSCILLATOR 3 kHz signal may be recorded, then the tape reproduced into the Flutter Meter. Test recordings should be made on high quality, low-noise tape that has been bulk erased before recording. The recording level and bias should be adjusted to provide the best possible signal-to-noise ratio at a high recording level. Since flutter is introduced both during the recording and again upon playback, one may assume the "standard" flutter is between 0.5 and 0.7 of the flutter indicated.

3-3.17 Instrument self check is performed by switching the Test Oscillator to 3 kHz, setting DRIFT SENSITIVITY to .3% and DRIFT meter to zero. Then switch test oscillator to +.3%. The drift meter should indicate +.3% ±5%. The meter should indicate -.3% ±5% when the Test Oscillator is switched to -.3%. The flutter indicator will also indicate a transient each time the frequency is switched.

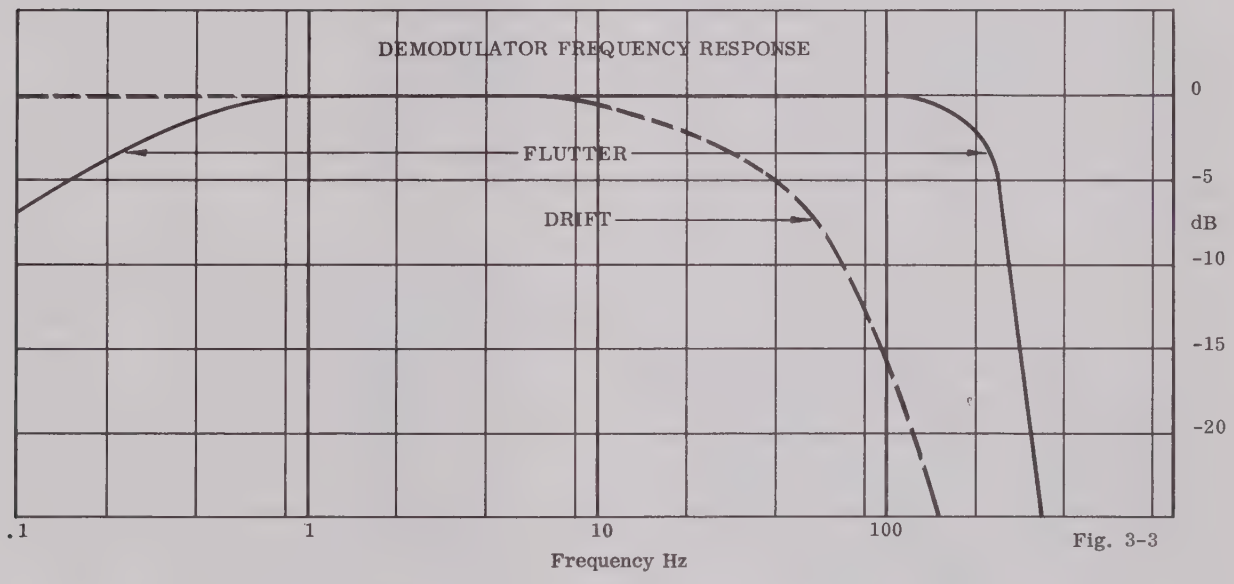


Fig. 3-3

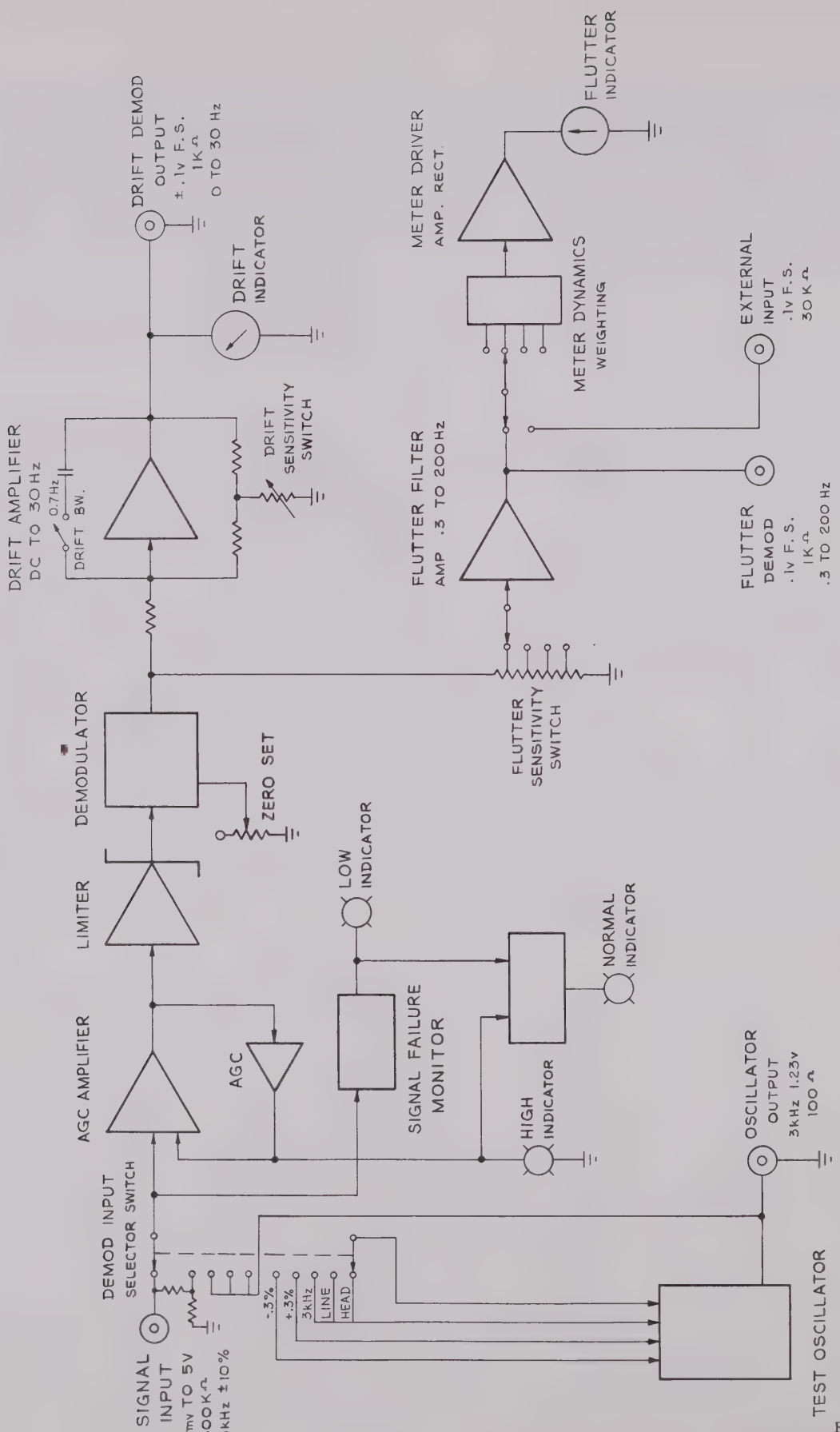

SIGNAL INPUT
5mv TO 5V
300KΩ
3kHz ±10%
DEMOD INPUT SELECTOR SWITCH
-3%
+3%
3kHz
LINE
HEAD
AGC AMPLIFIER
LIMITER
DEMODULATOR
ZERO SET
AGC
SIGNAL FAILURE MONITOR
LOW INDICATOR
HIGH INDICATOR
NORMAL INDICATOR
OSCILLATOR OUTPUT 3kHz 1.23v 100Ω
TEST OSCILLATOR
DRIFT AMPLIFIER DC TO 30Hz
0.7Hz
DRIFT BW.
DRIFT SENSITIVITY SWITCH
DRIFT INDICATOR
DRIFT DEMOD OUTPUT ±.1v F.S. 1KΩ 0 TO 30 Hz
FLUTTER FILTER AMP .3 TO 200Hz
FLUTTER SENSITIVITY SWITCH
METER DYNAMICS WEIGHTING
METER DRIVER AMP. RECT.
FLUTTER INDICATOR
EXTERNAL INPUT .1v F.S. 30KΩ
FLUTTER DEMOD .1v F.S. 1KΩ .3 TO 200 Hz

Fig. 4-1

SECTION IV

THEORY OF OPERATION

4-1 GENERAL DESCRIPTION

4-1.1 Models 8100 and 8100-W Flutter Meters include an AGC signal amplifier with a large dynamic range and high input impedance, a limiter, a frequency-to-voltage demodulator of exceptional precision, a DC drift amplifier, a bandpass active filter-amplifier for flutter, a meter driver amplifier-rectifier, a precision 3 kHz test oscillator, a highly regulated power supply, as well as signal sensing and level indicating circuits. Two meters independently indicate drift and flutter. The block diagram, Fig. 4-1, shows the overall scheme of this accurate, versatile instrument. The Model 8100-W also includes a .5 Hz to 600 Hz tunable wave analyzer.

4-2 BLOCK DIAGRAM DESCRIPTION

4-3 DRIFT MEASUREMENTS

4-3.1 To measure drift, the input signal is applied to the AGC amplifier through the DEMOD INPUT SELECT switch in the HEAD (5 to 200 mV) position or LINE (100mV to 5 V) position. The amplified signal, now at a constant level, goes to the limiter and, after frequency doubling, to the demodulator. The demodulator converts frequency to a voltage with exceptionally high precision by means of a patented circuit which causes a precision capacitor to be charged up to a reference voltage and discharged completely into a current-to-voltage amplifier once at each zero crossing of the input signal. Since the quantum of charge delivered at each zero crossing is equal to $-E_{ref} \times C$, the average current is equal to $-E_{ref} \times C \times 2f$. This current is offset by an opposite DC current derived through a wire-wound precision resistor from E_{ref} to make the output zero at the desired center frequency. Zero output at frequencies other than 3 kHz is obtained by varying the voltage to which the capacitor is charged with a very high resolution precision ZERO SET potentiometer. This method of zeroing the instrument causes the output indications to accurately reflect the % deviation from the actual input frequency, and not in terms of % of an arbitrary 3 kHz.

4-3.2 The filtered output of the demodulator goes to an operational feedback amplifier, the gain of which is controlled by changing the feedback factor with the DRIFT SENSITIVITY switch. The high frequency cutoff of the amplifier is controlled by capacitive feedback and may be switched from .7 Hz to 30 Hz ±20% by means of the DRIFT BW switch. In the SLOW position, the meter response is .2 Hz. The amplifier output drives the drift indicator and, after filtering, provides a DRIFT DEMOD signal of ±.1 V when the meter reads full scale.

4-4 FLUTTER MEASUREMENTS

4-4.1 The demodulator output also goes to the FLUTTER SENSITIVITY switch, thence to the Flutter amplifier, which is an active filter-amplifier. The sensitivity switch attenuates the input in the 10%, 3%, and 1% ranges, and sets the gain by feedback control in the .3%, .1%, .03% and .01% ranges. The filter-amplifier has a very flat pass band (±1/2 dB from 1.5 to 150 Hz) to 200 Hz and an extremely fast roll-off beyond 200 Hz. Residual carrier and system noise is less than .0005% rms at the output of the Flutter Amplifier. The FLUTTER DEMOD output is .1 V rms or ±.1 V peak full scale. The FLUTTER DEMOD output goes to the DEMOD position of the METER SELECT switch, then to the WEIGHTING switch. The WEIGHTING switch controls the gain, frequency response, and mode of driving the FLUTTER meter. In both NAB positions the meter will exhibit a VU dynamic response and is sensitive to the average of the signal after full wave rectification. Calibration is in terms of the rms value of a sinusoid having an average output indicated. In both DIN positions the meter reads ±peaks with appropriate charging and discharge time constants to meet DIN specifications.

4-4.2 The meter driver amplifier is a balanced operational amplifier with a full wave diode bridge output. Unique and exclusive feedback compensation effectively removes the nonlinear and thermal effects of the diode bridge from the output, resulting in an almost ideal AC meter that is linear even to the lowest portion of the scale. The METER SELECT switch permits an EXTERNAL METER AMPLIFIER input to drive the FLUTTER meter through the WEIGHTING switch and meter driver. 0.1 V rms external input causes the NAB position to read full scale; ±.1 V peak causes the DIN position to read full scale. The weighted positions for both NAB and DIN have a frequency response shown by Fig. 7 Sec. 1.

4-5 SIGNAL INDICATORS

4-5.1 The signal monitor circuit switches on the LOW SIGNAL lamp whenever the input level drops below 3.5 to 4 mV longer than 20 ms. This circuit, when switched, also removes the offset current from the demodulator and stops the quantum charge generator from functioning. In this way the meters are brought to zero when the signal is too low for accurate operation. When the INPUT SELECTOR switch is in the LINE position, the LOW lamp is turned on when the signal drops below approx. 85 mV longer than 20 ms. Whenever the signal input exceeds the range that the AGC circuit can handle, the HIGH signal lamp is turned on. Actuating either the LOW or HIGH lamp turns off the NORMAL SIGNAL lamp.

4-6 TEST OSCILLATOR

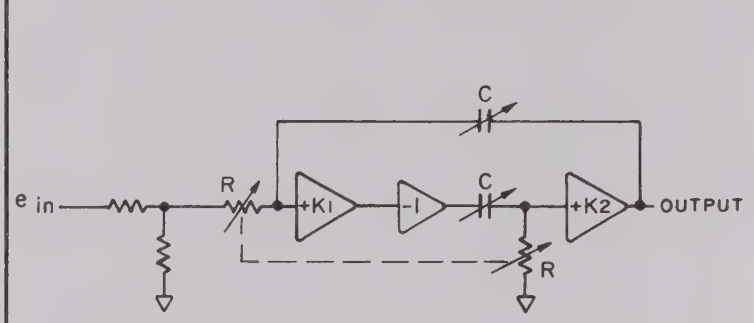
4-6.1 The test oscillator is an unusually stable LC oscillator operating at 3 kHz. A unique lamp bridge stabilizes the output amplitude at 1.23 V rms from a 100 ohm source. When the DEMOD INPUT SELECT switch is in the TEST OSC

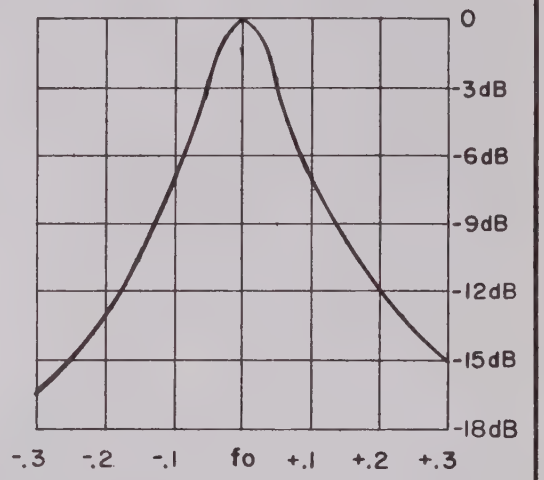
positions, a sample of the test oscillator is selected as input to the AGC amplifier. An elegant scheme is used to provide + and -.3% frequency deviations with high incremental accuracy; the DEMOD INPUT SELECT switch connects appropriate taps of the toroidal resonator inductor to produce frequency deviations of + or - 9 Hz ±.18 Hz at 3 kHz.

4-8 WAVE ANALYZER (Model 8100-W)

4-7 REGULATED POWER SUPPLY

4-7.1 The regulated power supply provides + 45.0 V ±.1 V and - 12 V ±.3 V with very good regulation and low impedance and ripple. The + 45 V supply is the reference for the precision frequency-to-voltage demodulator and is derived from a temperature compensated Zener reference diode. The - 12 V regulator uses the + 45 V supply as the reference for its regulator amplifier.





BLOCK DIAGRAM - WAVE ANALYZER

4-2

4-8.1 The wave analyzer is an active bandpass filter wherein the tuning is proportional to the inverse of two RC. products multiplied by the amplifier gain factor. The amplifiers are closely stabilized by feedback. Tuning within each band is accomplished by varying R with ganged, tapered wire wound potentiometers. Ranges are switched by changing C in decade steps with the METER SELECT switch. Selectivity is approximately .1 octave and the frequency dial calibration approximately logarithmic. When using the analyzer the WEIGHTING switch should be in either RMS or PEAK UNWTD position.

4-9 SCHEMATIC THEORY

4-10 SIGNAL AGC AMPLIFIER Card 8100-31

4-10.1 The signal AGC amplifier consists of a low noise, high impedance input stage including Q1 and Q2. The gain of this stage is 2 when C5 is ungrounded and approx. 10 when C5 is grounded by the HEAD position of the INPUT SELECT switch. The signal is attenuated by Q3, under control of the AGC circuit, and amplified further by feedback amplifier pair Q5 and Q6 to a 12 V peak-to-peak level. The amplifier has a 3 dB bandwidth from 2 kHz to 3.8 kHz. At 120 Hz the gain is falling at 18 dB per octave.

4-10.2 The signal output from the collector of Q6 causes diode CR2 to conduct when the peak-to-peak signal exceeds approx. 12 V. This current is filtered by C12 and is amplified by Q7 and Q8 to supply the AGC control voltage. Further filtering of signal frequencies in the AGC loop is provided by C9. The high gain in the AGC amplifier results in less than 1 dB change in output for a 50 dB change in input beyond the start of AGC action. The speed of the AGC action contributes to the very high suppression of 60 Hz and 120 Hz hum at the input. Q4 amplifies the input signal before limiting for use by the signal failure sensing circuit on card 8100-33.

4-11 NORMAL SIGNAL LAMP DRIVER

4-11.1 The NORMAL lamp is turned on by Q12 which is normally biased on through R43, CR6, CR7, and CR8. Whenever the LOW lamp is on, the NORMAL lamp is turned off by removing the forward bias on Q12 by conduction through CR9. Whenever the HIGH lamp is on, the NORMAL lamp is turned off by removing the forward bias on Q12 by conduction through CR5.

4-12 HIGH SIGNAL LAMP DRIVER

4-12.1 When the AGC amplifier control voltage exceeds approx. -9 V, Q9 is turned on through CR3. This turns on Q10 which causes Q11 to saturate on, thereby turning on the HIGH SIGNAL lamp. R17 is selected to cause the circuit to operate before excessive distortion of the input signal occurs in the AGC amplifier.

4-13 LIMITER, QCG, DEMODULATOR 8100-32

4-13.1 The amplified carrier is converted into square waves

by the squaring amplifier Q1 and Q3, which switch over a very narrow threshold near the zero crossings of the input. The square wave output is coupled to Q4 and Q5 which comprise a one-shot with a period of approx. 50 μsec. through CR2 and CR3. The one-shot is triggered once at each zero crossing, thereby doubling the input frequency. The output of the one-shot from the collector of Q5 turns on Q7 which is used as a precision switch to charge C9, a silver mica capacitor to a precisely controlled voltage once each cycle of the one-shot. During the period Q7 is turned off, C9 is brought to a controlled voltage near zero by R40 and R41 and clamp diodes CR4 and CR5. C9 is charged through CR9 and discharged through Q8, used as a common base amplifier. The voltage to which C9 is allowed to charge is controlled by the ZERO SET switch and vernier through Q6. The output pulses are integrated with C12 and mixed with a precision 1 ma current from R42 to provide zero output at the center frequency set by the ZERO SET dials. Output of the discriminator from the collector of Q8 goes directly to the drift amplifier input and through a low pass filter comprised by R45, R46, C11, and C15 to the FLUTTER SENSITIVITY switch as the input to the Flutter amplifier.

4-13.2 When the low level clamp actuates, a negative voltage through R19 turns off the squaring amplifier, thereby stopping the Quantum Charge Generator from delivering current pulses to the output. At the same time, CR8 is reversed biased, thereby removing the offset current from the output. Under these conditions the output is zero, and both meters are brought to their rest positions. The accuracy, linearity, and stability of the patented frequency-to-voltage converter is the basis for the precision of the MICOM 8100/8100-W Flutter Meters.

4-14 DRIFT AMPLIFIER, SIGNAL FAILURE CLAMP 8100-33

4-14.1 The Drift Amplifier is an operational DC amplifier with a balanced Silicon input transistor pair Q1 and Q2. Q1 and Q2 are selected for balance and mounted in close thermal coupling to maintain excellent balance. Gain is determined by feedback through R25 and R26 in conjunction with the input resistor, R6. The DRIFT SENSITIVITY switch, S3, attenuates the feedback signal to set the gain on all but the ±10% range. Bandwidth is determined by capacitive feedback: when the DRIFT BW switch is open, maximum bandwidth results. In the DRIFT BW FAST position C1, C2, C8, and C9 restrict the amplifier and meter response to 0.7 Hz. In the SLOW position the amplifier bandwidth is 0.7 Hz, but the meter response is restricted to 0.2 Hz. Positive feedback through R15 and R12 maintains an extremely low input impedance at all gain ranges to prevent interaction between the Drift amplifier and the Flutter amplifier. To insure low interaction in the presence of flutter signals many times larger than full scale input for the Drift amplifier, a clamp circuit consisting of Q9 and Q10 clamps the output by feedback whenever overload occurs. R30, C13 and R31, C14 form a low pass filter to minimize carrier components in the DRIFT DEMOD output, taken from the junction of R31 and R32.

4-14.2 The signal failure clamp is operated by the amplified input signal from Q4, card 8100-31. Whenever this signal is above approx. 0.42 V, Q7 is caused to switch on once each cycle, delivering a fixed increment of charge through C10 and CR2 into C15. Continued increments of charge above a 2 kHz rate turns off Q8, but if the signal fails, or falls too low, Q8 is allowed to turn on by the bias supplied through R34. When Q8 is on it drives Q11 into saturation, turning on the LOW SIGNAL lamp and removing the inputs to the Drift and Flutter amplifiers. C15 is large enough that momentary drop-outs of signal of up to 20 ms duration will not actuate the clamp, and hence will not interfere with the operation of the Flutter Meter.

4-15 FLUTTER AMPLIFIER, METER DRIVER 8100-34

4-15.1 The Flutter amplifier is an active-filter amplifier designed to provide very flat response from .3 Hz to 200 Hz and attenuate all signals above 3 kHz more than 100 dB. The input impedance of the amplifier is 100 kilohms and gain and DC operating points are stabilized by potentiometric feedback to the emitter of Q1. The frequency response of the amplifier is shaped to compensate for the droop within the pass band caused by the low-pass filter in the demodulator. Shaping is provided by controlling the phase of the feedback signal with the network of R31, C13, R27, and C11. The corner of the pass band is squared and the slope of attenuation above the pass band made very steep by a bridge action provided by R37, R38, and C15 in conjunction with the rest of the feedback network. Gain is controlled by switched precision resistors R5, R6, and R7 on SW4, shunting the feedback path. High level inputs are attenuated by precision resistors R1, R2, R3, and R4 on SW4. A low output impedance is insured by the overall feedback as well as by use of Q4 as an emitter follower. The DRIFT DEMOD output is isolated and brought to a standard 1 kilohm impedance with R18.

4-15.2 The meter driver is an operational DC amplifier with exceptional DC stability. Q6 and Q7, a matched pair of high gain Silicon planar transistors, are in close thermal contact to minimize drift. Gain is determined by the ratio of the feedback resistor R25 to the input resistor R12 on SW5. The output is from a full-wave diode bridge, CR2, CR3, CR6, and CR7. An exclusive compensation scheme which includes CR4, CR5, CR8, and CR9 within the feedback path effectively removes the imperfections of the diode bridge from the output terminals. Not only does the meter driver provide an output that is linear down to low levels when driving the meter as an average rectifier in making NAB "rms" measurments, but the effective impedance is extremely low to pulse currents necessary to provide the fast charging time demanded by the DIN quasi-peak indication. The development of this meter driver permits the use of one meter to satisfy the requirements of both NAB and DIN standards with one instrument.

4-15.3 The shaped frequency response required by the weighted measurments called for in both standards is provided by R16 and C17 as additional high frequency feedback to the input. The low frequency shaping is provided by C3 and C5 on SW5, in series with the normal coupling networks, C7 or C4, C6 and R16 in series with C7.

4-15.4 The gain of the amplifier is such that .1 V rms causes the meter to read full scale in the NAB UNWTD position and ±.1 V peak causes the meter to read full scale in the DIN UNWTD position. R9 and R10 on SW5, METER SELECT, are selected in calibrating NAB meter indications. R11 and C1 determine peak charging time and R14 and R15 are selected in calibrating DIN indications. R13 and C2, if used, are to control the dynamic response of the meter to conform to V.U. standards.

4-16 TEST OSCILLATOR 8100-35

4-16.1 The test oscillator is based on a two stage amplifier with positive and negative feedback to a tuned LC circuit at its input. L1 and C4-C7-C10 (in series with C5 and C6) determine the frequency of oscillation. Q4 is a voltage amplifier, Q3 a phase splitter power stage. Positive feedback through R9 and R10 is combined with negative feedback through R6 and coupled to the resonator at the impedance dividing capacitors C5 and C6. Amplitude stabilization is provided by the action of DS1, an incandescent lamp, which increases its resistance as the signal increases. Increased resistance coupled to the emitter of Q3 not only increases the negative feedback to the input, but also reduces the positive signal at the collector of Q3. R10, a 15 turn wire-wound potentiometer, is used to adjust the output amplitude to the desired value. Q1 and Q2 are a feedback pair providing an output voltage of 1.23 V rms at a very low impedance. R1 and C1 provide an output impedance of approx. 100 ohms at 3 kHz. A unique means of switching frequency in + or - 0.3% increments with very high accuracy is employed. The resonator inductor is a very tightly coupled, high Q toroid and has taps at precisely + and - 0.3% of its overall turns. By switching to the appropriate tap with the DEMOD INPUT SELECT switch the frequency may be shifted up or down 0.3% from the center frequency. C10 permits fine adjustment of frequency C8 and C9, if used, control the exact frequency shift in the + and - 0.3% positions. A very small sample of the output through R2 is used as a test input to the Flutter Meter.

4-17 POWER SUPPLY AND REGULATOR 8100-30 (M201-30)

4-17.1 The power supply has a 115/230V, 50 - 60 Hz power transformer, T1, with two secondaries. One secondary provides approx. 60 V full wave rectified voltage to C1. The other secondary provides approx. 25 V full wave rectified voltage to C2. The + 45.0 V supply is controlled by Q1 as a series regulator, driven by Q7, which amplifies the error signal from Q6. Q6 amplifies the difference between the voltage on its base, a fraction of the output voltage, and the voltage maintained across Q5 which is operated as a Zener diode at approx. 6.3 V. The choice of Q5 was made to provide a stable reference voltage which has a temperature coefficient of break-down voltage which compensates for the temperature coefficient of V_{BE} of Q6. The combination used has an almost zero temperature coefficient over a large ambient range. The regulated output voltage is determined by the divider R12 + R13 ∓ R14. R12, a 15 turn wire-wound trimmer, permits adjustment of the output voltage to 45.0 V ±.01 V. This voltage is the reference for the precision demodulator and should be maintained at 45.0 V, although the demodulator has a first order self compensation to variations in the reference. The high gain of the regulator loop results in a very low output impedance and less than 1 mV ripple at 120 Hz. The voltage drop across CR5 provides a +46 V bias. Q2 regulates the -12.0 V supply and is controlled by Q4, an error amplifier. Q4 compares the ratio of the output of Q2 to the 45 V reference, as determined by R6 and R7, and amplifies the error voltage in a sense to reduce the error. Q3 provides a constant current source to the collector of Q4 to keep the voltage gain as high as possible. C5 provides a low impedance path for ripple at the output to the input of the regulator, resulting in an output ripple less than 4 mV. C2 and C3 reduce the output impedance of the supplies to high frequency currents. R1 and R2 are protective impedances to fault currents.

4-18 WAVE ANALYZER M8100-36 (MICOM MODEL 8100-W)

4-18.1 The wave analyzer is an active filter with two amplifier sections. Q1, Q2, and Q3 comprise a feedback stabilized amplifier with a gain of +20. Q4 provides a gain of -1 with a very low output impedance. Coupling to the second stage is through the METER SELECT switch in the Wave Analyzer frequency multiplier positions and C6, C7, or C8. Q5, Q6, and Q8 comprise a feedback amplifier with a gain of approx. +20. Q7 establishes a low impedance bias for the second stage. R25, a screwdriver adjust wire-wound resistor is used to set the gain and hence the frequency calibration. The output, from the emitter of Q8 is coupled to the input through the multiplier positions of the METER SELECT switch and C1, C2, or C3. R1, a special tapered wire-wound ganged potentiometer, in conjunction with the coupling capacitors, permits tuning the frequency of maximum response. R5 and R21 are selected in calibration of the high frequency end of the tuning range. R3 is selected to provide an overall gain of 1 at the frequency of maximum response. R2 and C10 are selected to provide uniform response to 600 Hz. R28 is selected to establish the DC operating point of the output at near zero volts. C4, R11; C5, R17; and C9, R27 are taming networks necessary for high frequency stability.

SECTION V

MAINTENANCE

5-1 INTRODUCTION

5-1.1 This section provides maintenance and service information for the Model 8100/8100-W Flutter Meter. These are precision instruments designed to provide long, trouble-free service without requiring maintenance or adjustments. To check the calibration of the instrument to full accuracy will require instruments not normally available except in the largest laboratories. If trouble is experienced with an instrument, it is recommended that the instrument be returned for prompt repair or recalibration to:

MICOM, Incorporated
855 Commercial Street
Palo Alto, California 94303
Telephone (415) 328-2961

5-2 TEST EQUIPMENT

5-2.1 Recommended test equipment for performance checking and troubleshooting is listed in Table 5-1. Other instruments can be used if their performance or specifications equal or exceed the required characteristics.

5-3 INSTRUMENT COVER REMOVAL

5-3.1 Unscrew and remove the six countersunk Phillips-head screws holding each cover on. Covers may then be lifted off. To remove cards from the card cage, remove the rear plate held in place with four 6-32 screws.

5-4 TROUBLESHOOTING AND REPAIR

5-4.1 SELF CHECK: When a malfunction is suspected, disconnect all equipment from the instrument and perform the self-check procedure given in Figure 3-2. If the instrument self checks properly, check that the input is within the frequency and amplitude limits of specifications. For example, the test input signal may be intermittent, contain a large interfering component, or have a poor signal-to-noise ratio. Damaged connecting cables may be causing intermittent connections or noise. If the malfunction still persists, make performance checks to help determine the location of the trouble.

5-4.2 SUBSTITUTION: Troubleshooting is greatly simplified if checking is done by replacing a suspected plug-in circuit card with one known to be operating properly. When a malfunctioning card is found, trouble may be traced to the offending component, or the card returned to MICOM for repair.

5-4.3 TROUBLESHOOTING OF CIRCUIT CARDS: Refer to Section IV, Principles of operation, for details on the operation of all assemblies used in the Model 8100/8100-W. Reference to the schematic for each circuit card will enable circuit tracing on a card. For easy access to operating plug-in cards, a PC board extender will greatly facilitate testing an individual board.

5-4.4 PRINTED CIRCUIT COMPONENT REPLACEMENT: To prevent damage to the circuit board, apply heat sparingly and work carefully. A 37-1/2 Watt iron with a small, clean tip is recommended. The replacement procedure is as follows:

a. Remove the defective component.

b. Melt solder in component lead holes and remove the excess solder with a clean, dry iron. Clear holes with a thin toothpick or a suction type solder removal tool, pushing from the trace side of the card.

Table 5-1

RECOMMENDED TEST EQUIPMENT

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	RECOMMENDED EQUIPMENT
DC VT Voltmeter	10mV to 100V 0.1% full-scale accuracy	H-P Model 3430A
AC VT Voltmeter	10mV to 10V 1.0% full-scale	H-P Model 400H
Oscillator	0.1 Hz to 10 kHz	Optimation Model RCD-1
Electronic Counter	Frequency to 10 kHz, 1 and 10-second gate Accuracy 0.01%	H-P Model 3734A
Precision Frequency Modulator	Center frequency 3 kHz ±10% 10% modulation range with 0.1% linearity	MICOM Model 9100 FM Test Set
Oscilloscope	10mV/div to 10V/div DC to 15 mHz	Tektronix Model 422

c. Bend leads of the replacement component to fit, and insert the component leads in the holes. Solder the leads in place, using heat and solder sparingly.

d. If a pad or printed circuit trace is lifted, press conducting pad against the board and hold until solder cools so that the component lead holds the pad firmly in place.

5-5 PERFORMANCE CHECKS AND CALIBRATION

5-5.1 POWER SUPPLY:

a. Set line voltage to normal value: 115V or 230V ac.

b. The +45V supply rail (Pin 15 on any PC socket) should measure 45 ±0.1V dc. If outside this range, adjust R12 (15-turn screwdriver pot) on Card 201-30.

c. The -12V supply rail (Pin 1 on any PC socket) should measure -12.2 ±0.5V dc. If outside this range, replace R7 (2.67K 1% resistor) with a selected metal film or wire-wound resistor to bring within tolerance.

d. Vary line voltage from 105 to 130V ac or from 210 to 260V ac. The +45V rail should not vary more than ±0.1V dc.

5-5.2 TEST OSCILLATOR:

a. Connect OSC OUTPUT to frequency counter and measure frequency. With the DEMOD INPUT SELECT switch at 3 kHz, the output frequency should be 3000 ±3 Hz. If outside this range, adjust C10 (screwdriver adjust ceramic capacitor on Card 8100-35) to bring within tolerance. Switch to +0.3%; frequency should increase 9 ±0.2 Hz. Switch to -0.3%; frequency should decrease 9 ±0.2 Hz. If necessary, C18 and C19 may be used to make minor adjustments in ΔF. These capacitors should be tantalum in the 3 to 20 μF range. C19 should be approximately twice as large as C18.

b. Connect OSC OUTPUT to distortion analyzer. Output voltage should be 1.23V rms and distortion less than 3%. Level may be adjusted with R10 (15-turn screwdriver pot) on Card 8100-35. Excessive distortion is evidence of improper bias (check R14 and R15) or failed transistor. Refer to Section 4-16 and Schematic 6-7 to troubleshoot.

5-5.3 SIGNAL INPUT THRESHOLDS:

a. Connect sine wave oscillator (H-P 651A or equivalent) to SIGNAL INPUT BNC connector with AC Voltmeter (H-P 400H or equivalent) monitoring the input, and measure threshold at which low-level indicator turns off. The low threshold should be between 3.5 and 5mV rms when the DEMOD INPUT SELECT switch is in the HEAD position, and between 80 and 100mV rms in the LINE position. The high-level indicator should turn on when the input level is between 200mV rms and 300mV rms when in the HEAD position, and should not turn on until the input exceeds 5V rms in the LINE position. Refer to Section 4-14.2 and Schematic 8100-33 for operation of low-level circuit, and Sections 4-11 and 4-12 and Schematic 8100-31 for operating details of the high and normal indicator circuits.

5-6 DRIFT CALIBRATION

a. Adjust the mechanical zero of the DRIFT meter to center the needle. Turn the instrument on and switch the DEMOD INPUT SELECT switch to 3 kHz. With DRIFT % FULL SCALE switch on 1% range and ZERO SET at 0.00, check meter indication. If indication is outside ±0.1% drift, adjust C11 (screwdriver adjust ceramic capacitor) on Card 8100-32 to center the needle.

b. Connect the output of the Model 9100 Test Set to the SIGNAL INPUT BNC connector and a DC Voltmeter (H-P 3430A or equivalent) to the DRIFT DEMOD output BNC connector. Switch the Model 9100 to 3.125 kHz test frequency and to zero deviation (EXT MOD).

c. Switch % FULL SCALE DRIFT to 10%, DRIFT BW to FAST, and zero the meter with ZERO SET control. Switch the 9100 Modulator to +10% deviation; DRIFT DEMOD output should be +100mV ±2mV, and DRIFT meter should read +9.5 to +10.5% drift. Switch Modulator to -10% deviation; DEMOD output should be -100mV ±2mV, and DRIFT meter should read -9.5 to -10.5%.

d. Switch % FULL SCALE to 3% and zero the DRIFT DEMOD output with ZERO SET control with zero deviation of Modulator, then measure output with a + and -3% deviation. Output voltage should be +100 ±2mV and -100 ±2mV respectively.

e. Check the 1.0%, 0.3%, 0.1%, and 0.03% ranges of the Model 8100 Meter in a similar manner, zeroing the DRIFT DEMOD output with the ZERO SET control for each range. Because of the difficulty in adjusting the output to zero on the 0.03% range, a span of 200mV ±4mV, centered at ±10mV from +0.03% deviation to -0.03% deviation is satisfactory.

f. If all DRIFT DEMOD ranges are in error, check the operation of the QCG, Card 8100-32. If the demodulator is normal, adjust R31 (Card 8100-33) to provide the best compromise on all ranges. Precision resistors on S3, % FULL RANGE DRIFT, control the output on the 3.0%, 1.0%, 0.3%, 0.1%, and 0.03% ranges. Appropriate selection of R5 will control the output on the 3.0% range, R4 on the 1.0% range, R3 on the 0.3% range, R2 on the 0.1% range, and R1 on the 0.03% range. If the meter is in error, shunting R29 with a selected composition resistor will increase the indication, and shunting the DRIFT meter terminals will decrease the indication.

5-6.1 DRIFT BANDWIDTH:

a. Modulate the Model 9100 Test Set with a 4V ±1% peak-to-peak (1.414V rms) sine wave from a Wavetek Model 110 or equivalent function generator. Set % MODULATION to 1%, set Model 8100 % FULL SCALE DRIFT sensitivity to 1%, and set DRIFT BW in the 30 Hz position.

b. Measure DRIFT DEMOD output with a H-P 400H or equivalent AC Voltmeter. The output should be down 3 db from 100mV peak to peak at from 24 to 36 Hz modulation frequency (voltmeter reading at -3 db will be 25mV rms).

c. FAST DRIFT BW may be checked by modulating the 9100 Test Set with an 8V peak-to-peak sine wave and noting the frequency at which the meter indicates + and -71% full-scale deviation. This frequency should be between 0.56 Hz and 0.84 Hz. Similarly, the SLOW DRIFT BW should indicate + and -71% full-scale peak deviation at from 0.16 Hz to 0.24 Hz modulation frequency.

5-7 FLUTTER TEST AND CALIBRATION

5-7.1 FLUTTER AMPLITUDE:

a. Flutter checks are made with the Model 9100 Test Set operated at 3.125 kHz center frequency, externally modulated with a ±4V ±0.1% peak sine wave (2.83V ±0.1% rms) or a 4V ±0.1% rms sine wave. Zero the DRIFT DEMOD output with the ZERO SET control.

b. With the Model 8100/8100-W turned on and the METER SELECT switch in the EXTERNAL position, adjust the mechanical zero of the flutter indicator to zero. After adjustment, back off adjusting screw to free meter movement.

c. Connect the output of the Model 9100 Test Set to the input of the 8100/8100-W. Set the WEIGHTING switch (S5) to NAB UNWTD. Modulate the 9100 with a 4V ±0.1% rms sinusoidal signal at 40 Hz. Measure the FLUTTER DEMOD output with a H-P 400H AC Voltmeter or equivalent.

d. With 10% modulation and the % FULL SCALE FLUTTER switch at 10%, the FLUTTER DEMOD output should be 100 ±2mV rms. Check each sensitivity range with corresponding % modulation and % FULL SCALE sensitivity. The FLUTTER DEMOD output should be 100 ±2mV rms on each range except on the 0.01% range, where instrument and system noise may result in a very slightly higher reading.

e. If all ranges are in error, adjust R39 on Board 8100-34. If a particular range is in error more than ±2%, replace the appropriate resistor on S4, % FULL SCALE FLUTTER switch. R3 controls the 10% range, R2 the 3% range, R1 the 1% range, R7 the 0.1% range, R6 the 0.03% range, and R5 the 0.01% range.

5-7.2 FLUTTER BANDWIDTH:

a. With 1% 40 Hz as reference, find the frequency at which output is down 3 db. If outside the range of 190 to 220 Hz, replace C15 with a selected stable capacitor to bring within tolerance. Check frequency response throughout band as within +0.2 db -0.8 db from 1.5 Hz to 150 Hz. At frequencies below 20 Hz, a dc oscilloscope may be used as an indicator. The low frequency -3 db point should be between 0.2 and 0.36 Hz.

5-8 METER AND WEIGHTING TESTS

a. NAB UNWEIGHTED CALIBRATION: With 1% rms sinusoidal modulation at 40 Hz as an input and with the % FULL SCALE FLUTTER at 1%, the FLUTTER meter should indicate from 95% to 105% full scale. R10 on S5, WEIGHTING switch, controls the NAB UNWTD response. A step change in modulation from <1% full scale should cause the meter to overshoot between 0.5 and 2%. R13, if used, adjusts the damping and, if changed, will require recalibration of all weighting positions. The meter response should be flat +0.5 -1.0 db between 1.5 and 150 Hz, and should be 3 db down between 0.4 and 0.6 Hz and between 190 and 220 Hz. At low frequencies, where the meter can follow the input waveform, the peak response is measured.

b. NAB WEIGHTED CALIBRATION: In the NAB WTD position, 1% sinusoidal modulation at 4 Hz should cause an indication between 95 and 105%. R9 on S5 controls the meter response in the NAB WTD position. The weighted frequency response should fall within the limits shown in Figure 7, Section 1-5. C17 on Card 8100-34 controls the high frequency roll-off of both weighted positions; C3 on S5 controls the low frequency roll-off in the NAB WTD position.

c. DIN UNWEIGHTED CALIBRATION: With 2.83V ±0.1% rms modulation of the 9100 Test Set, 1% modulation, and 1% FULL SCALE FLUTTER sensitivity, the FLUTTER meter should indicate from 95% to 105% full scale at a 40 Hz modulation rate. R15 on S5 controls the meter response in the DIN UNWTD position.

d. DIN WEIGHTED CALIBRATION: With a 4 Hz modulation which produces full-scale indication in the DIN UNWTD position, the FLUTTER meter should indicate from 98% to 102% of full scale in the DIN WTD position. R14 on S5 controls the meter response in the DIN WTD position.

5-9 WAVE ANALYZER TEST (8100-W ONLY)

a. Modulate the 9100 Test Set with a 20 Hz sinusoidal signal of sufficient level to provide full-scale indication when the 8100-W is tuned to maximum response, near 2 on the Hz dial, and when in the X10 position of the METER SELECT switch. Find frequencies above and below the peak response at which the meter response is 71% of the maximum. The difference between these frequencies should be between 0.8 Hz and 1.2 Hz. If outside this tolerance, adjust R25 (Card 8100-36) to provide 10% ±1% bandwidth. Note that changing the setting of R25 will require resetting the amplitude calibration and may require repositioning the Hz dial for best frequency tracking.

b. Check dial position for maximum response with 5 Hz modulation; reset dial if necessary.

c. Check dial position for 50 Hz modulation; replace R5 and R21 if necessary to provide tracking to within 5% of the dial calibration.

d. Check uniformity of peak response at 5 Hz, 20 Hz, and 50 Hz. The amplitude should be constant within ±1 db at those frequencies. Differential adjustment of R5 and R21 may be used to change the peak response at 50 Hz if necessary.

e. With 2 Hz modulation, check peak response when Hz dial is tuned for maximum on the X1 range. Response should be ±0.5 db of response at 20 Hz. Minor adjustment of C3 or C8, if necessary, may be made to adjust peak response at 2 Hz. Check that peak response at 0.5 Hz, 2 Hz, and 5 Hz is within ±1.5 db peak response at 20 Hz. At 0.5 Hz, readjust the modulator level to produce full-scale output with the METER SELECT switch in the DEMOD position. On the X1 range, tuning must be extremely slow, and sufficient time must be allowed for the analyzer to reach its peak response at each setting.

f. With 100 Hz modulation, check peak response when the Hz dial is tuned for a maximum on the X100 range. Response should be ±0.5 db of peak response at 20 Hz. Minor adjustment of C1 or C6, if necessary, may be made to adjust peak response at 100 Hz. Check that the response at 50 Hz is ±1 db of that at 100 Hz, and that the response is -2 to -3 db below the 100 Hz response at 200 Hz.

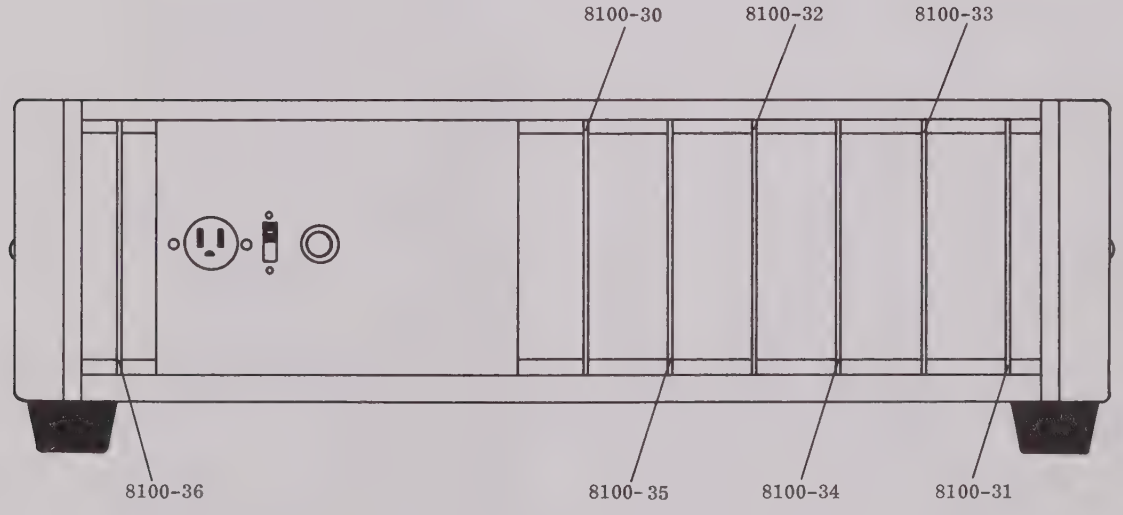
g. With 20 Hz modulation, adjust modulation level to provide 90% indication on the meter when the METER SELECT switch is in the DEMOD position. Switch to X10 and tune to maximum indication. The meter should indicate 85 to 95% full scale. If outside this tolerance, change R3, a selected composition resistor, to set overall gain.

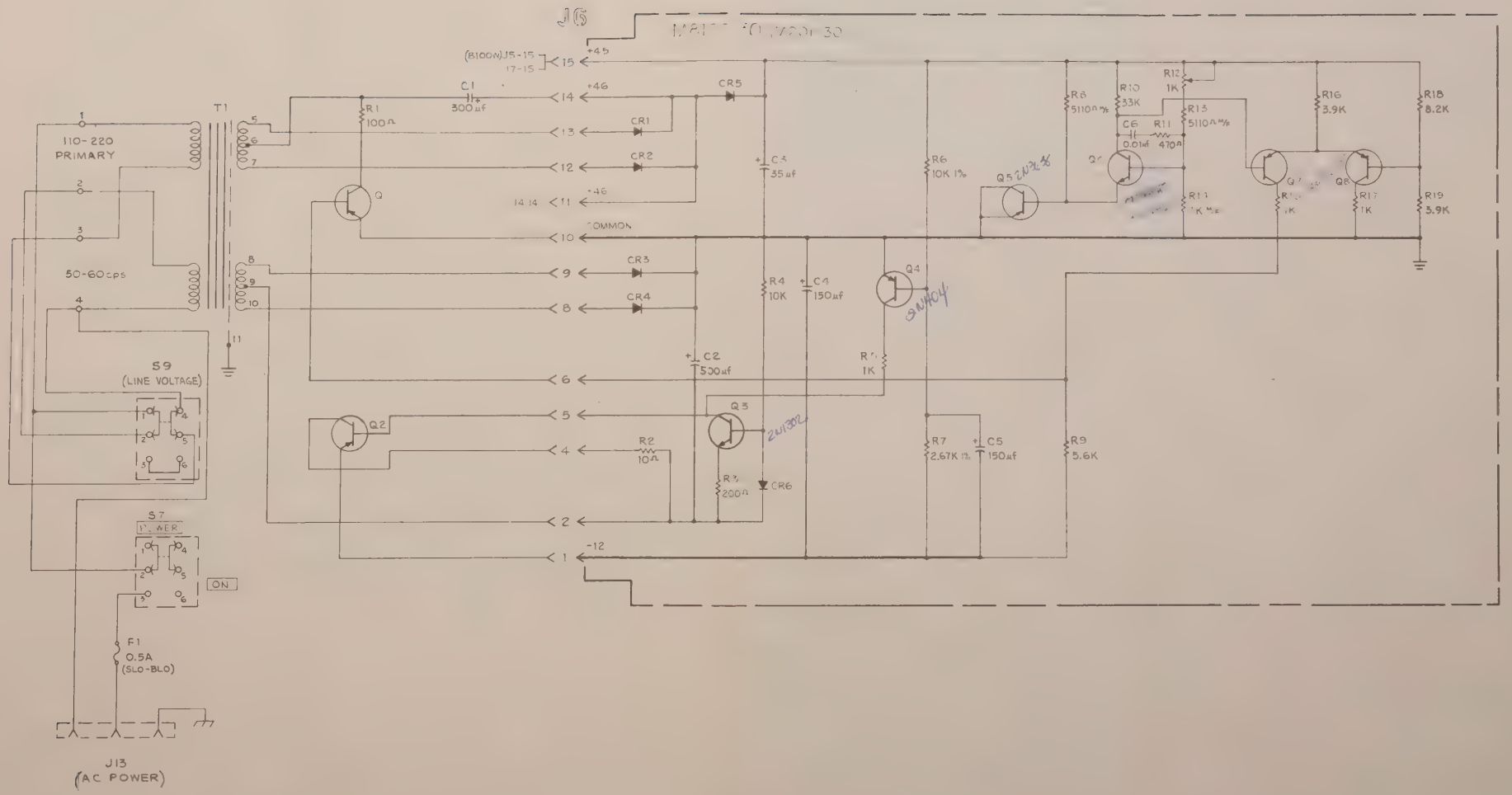
SECTION VI

SCHEMATIC DIAGRAMS

6-1 SCHEMATIC DIAGRAMS

6-1.1 This section contains the schematic diagrams necessary for operation and maintenance of the MICOM Models 8100 and 8100-W Flutter Meters. The schematic diagrams illustrate the circuits on each plug-in card. Interconnections and switch-mounted components are shown on Fig. 6-8. Component values marked Δ are nominal, optimum value selected at factory, or may be omitted.





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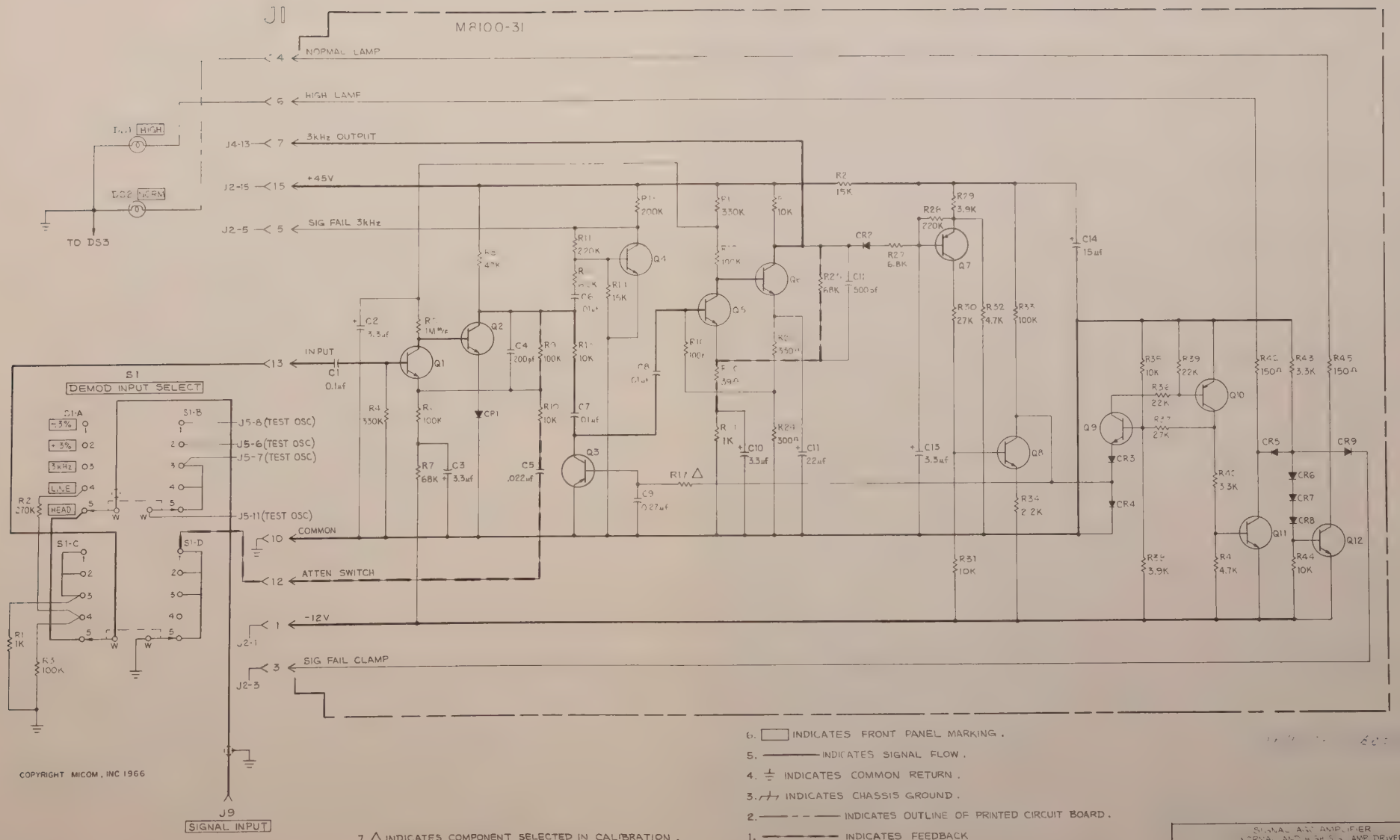
4. ▭ INDICATES FRONT PANEL MARKING.
3. ⏚ INDICATES CHASSIS GROUND.
2. ⏚ INDICATES COMMON RETURN.
1. ——— INDICATES PRINTED CIRCUIT CARD OUTLINE.

NOTES:

POWER SUPPLY AND REGULATOR	
	DRAWING NUMBER M810030



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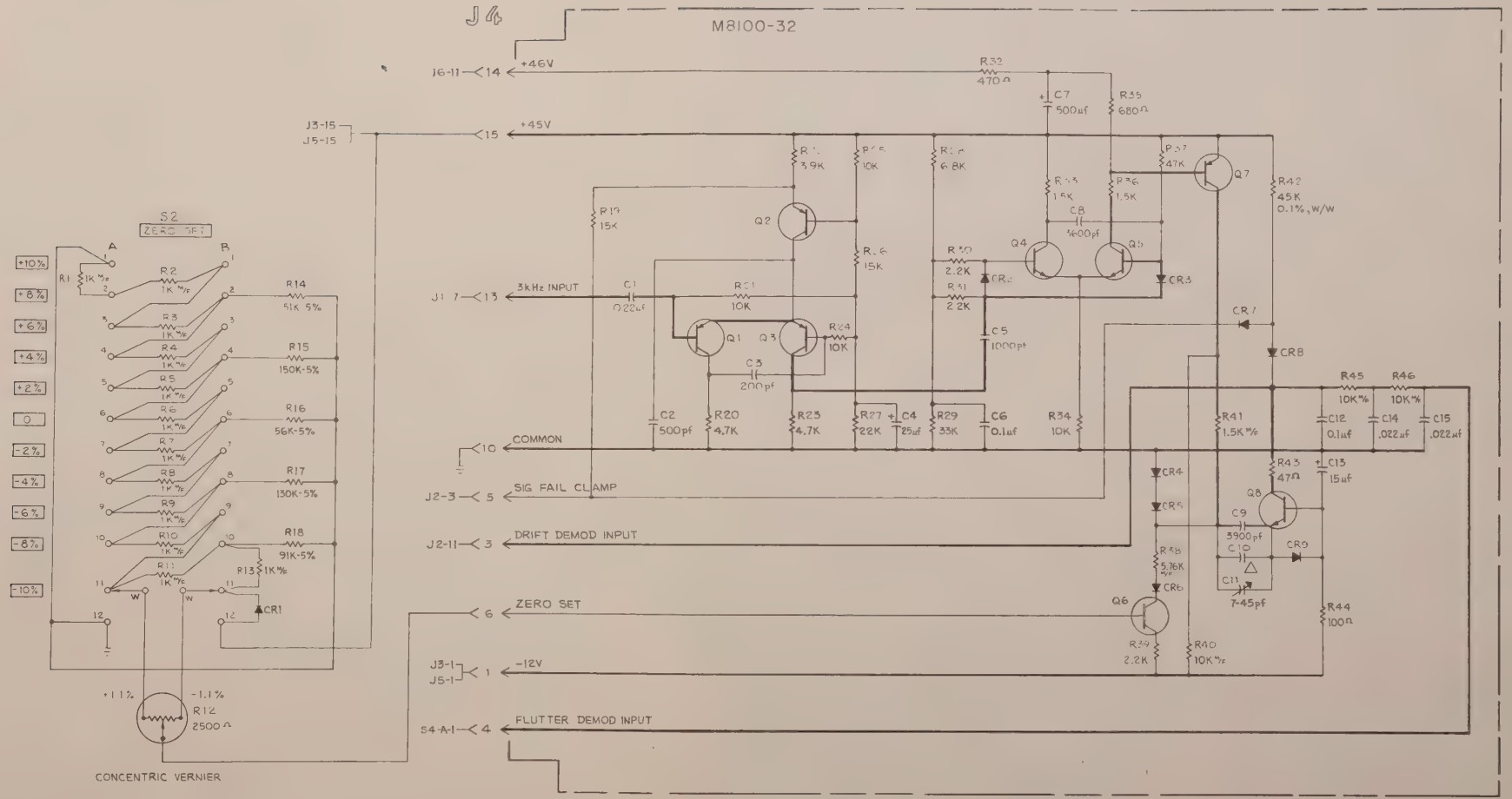
6. ▭ INDICATES FRONT PANEL MARKING.
5. ——— INDICATES SIGNAL FLOW.
4. ⏚ INDICATES COMMON RETURN.
3. ⏚ INDICATES CHASSIS GROUND.
2. — — — INDICATES OUTLINE OF PRINTED CIRCUIT BOARD.
1. ——— INDICATES FEEDBACK

NOTES:

7. △ INDICATES COMPONENT SELECTED IN CALIBRATION.

SIGNAL AND AMPLIFIER NORMAL AND HIGH GAIN AMP DRIVER	
	DRAWING NUMBER M8100 31



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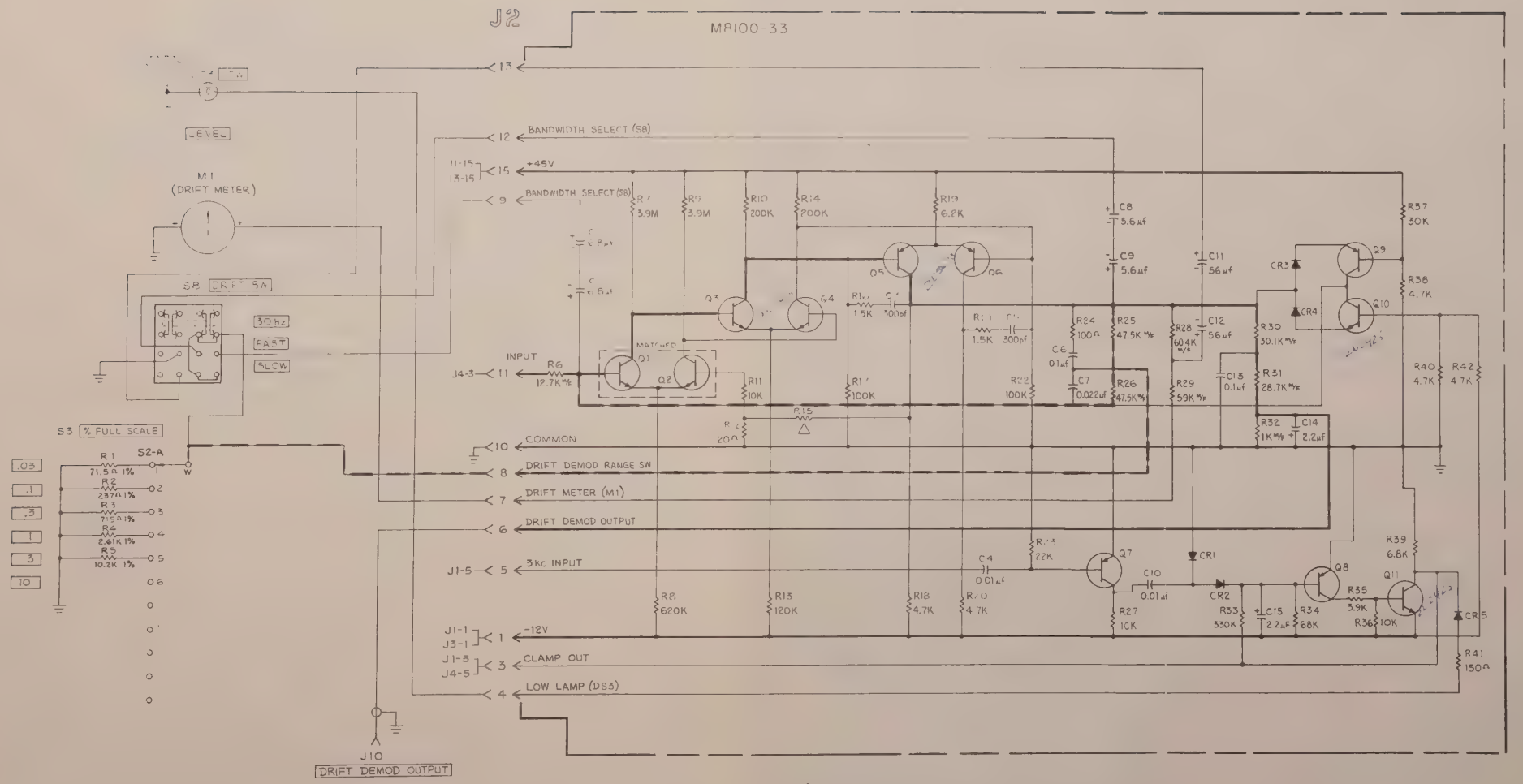
5. △ INDICATES COMPONENT SELECTED IN CALIBRATION.
4. ⏚ INDICATES COMMON RETURN.
3. ——— — — INDICATES OUTLINE OF PRINTED CIRCUIT BOARD.
2. ——— INDICATES SIGNAL FLOW.
1. ▭ INDICATES FRONT PANEL MARKING.

NOTES:

LIMITER, QCG, DEMODULATOR SCHEMATIC DIAGRAM	
	DRAWING NUMBER M8100-32



6. △ INDICATES COMPONENT SELECTED IN CALIBRATION.
5. ⏚ INDICATES COMMON RETURN.
4. ——— INDICATES FEEDBACK PATH.
3. — — — — INDICATES PRINTED CIRCUIT CARD OUTLINE.
2. ——— INDICATES SIGNAL FLOW.
1. ▭ INDICATES FRONT PANEL MARKING.

NOTE:

DRIFT AMPLIFIER, SIGNAL FAILURE CLAMP
M810033

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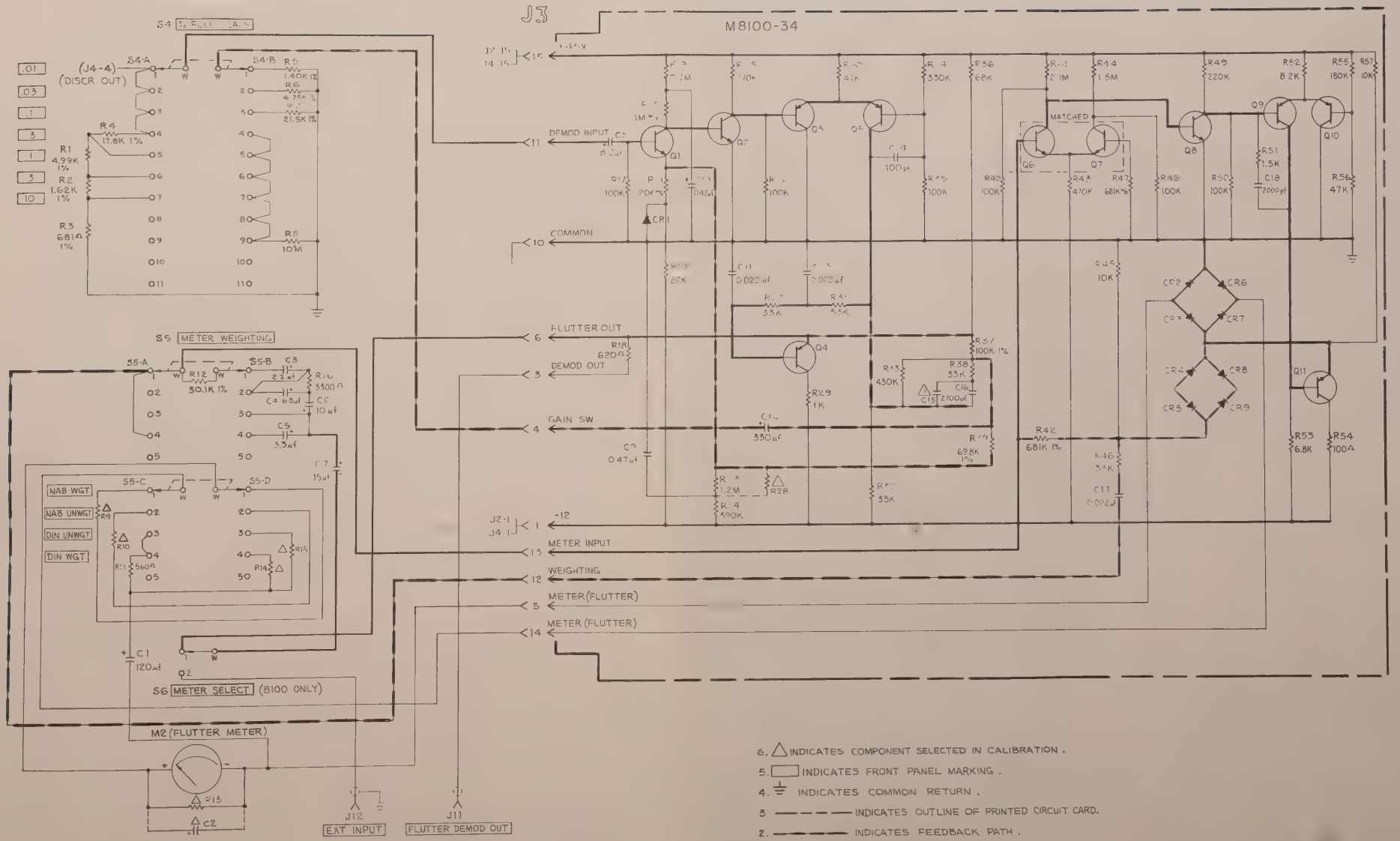

6. △ INDICATES COMPONENT SELECTED IN CALIBRATION.
5. □ INDICATES FRONT PANEL MARKING.
4. ⏚ INDICATES COMMON RETURN.
3. — — — — INDICATES OUTLINE OF PRINTED CIRCUIT CARD.
2. ——— INDICATES FEEDBACK PATH.
1. ——— INDICATES SIGNAL FLOW.

NOTES:

FLUTTER AMPLIFIER, METER DRIVER
M8100-34

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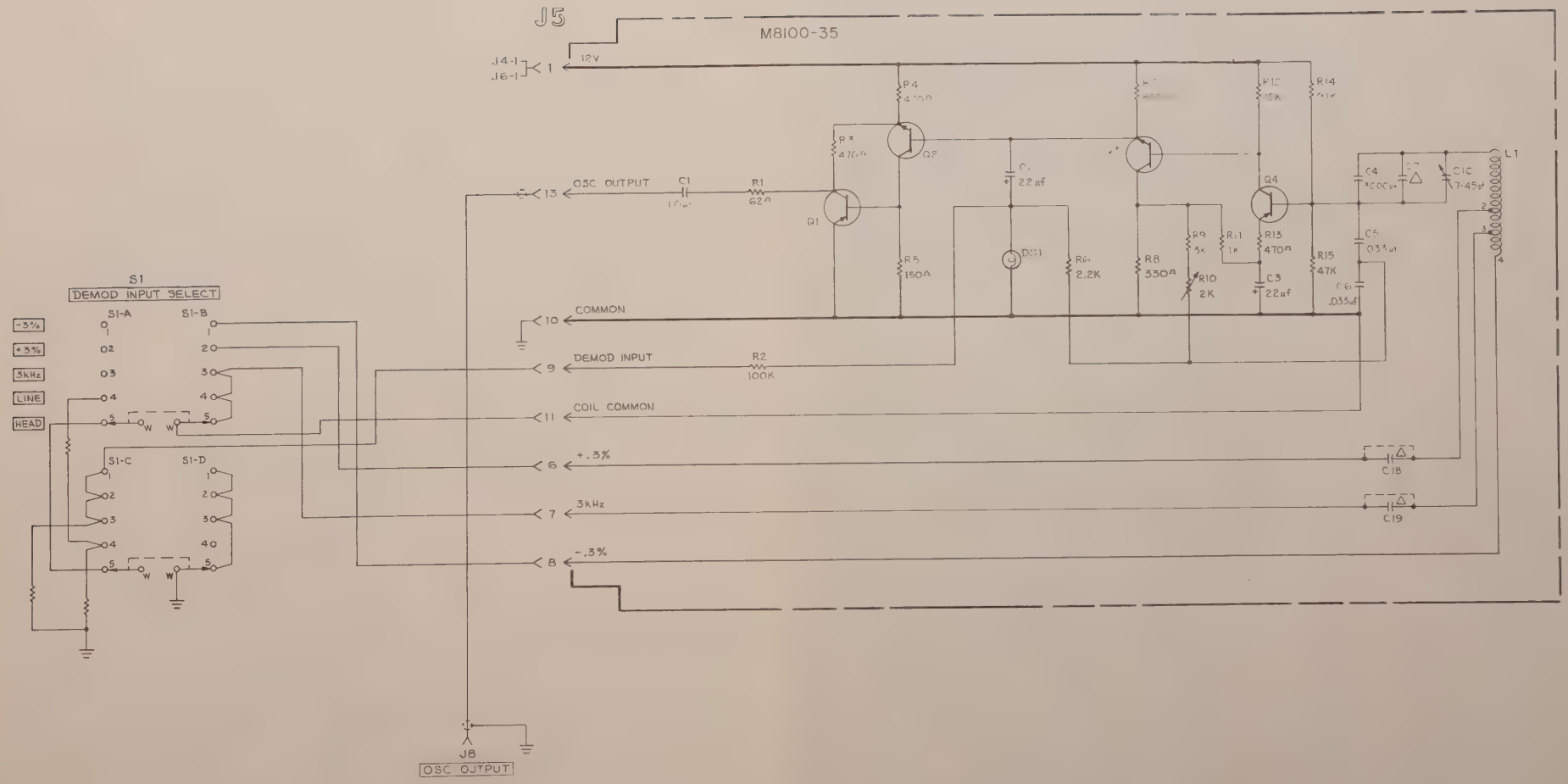

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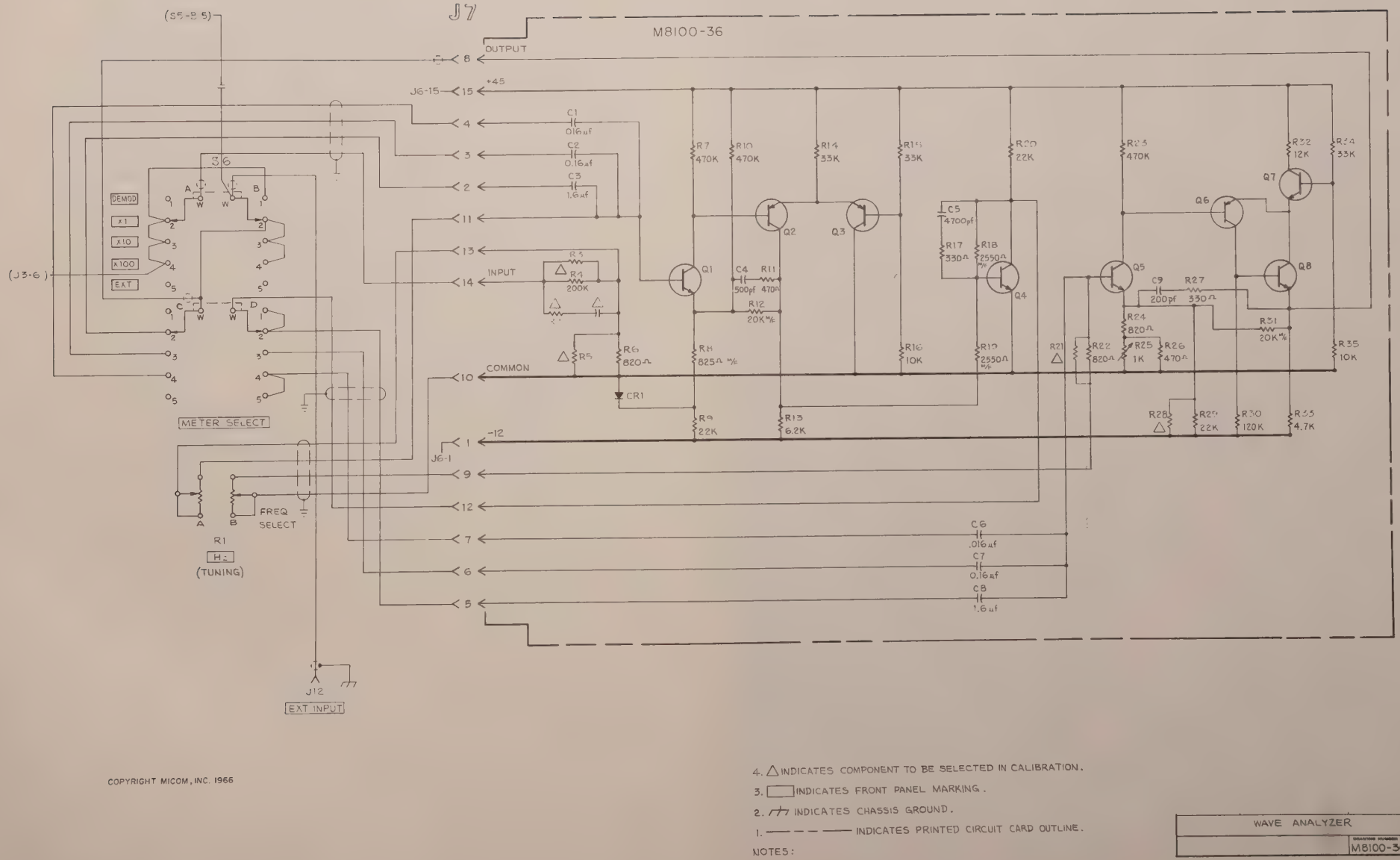
4. △ INDICATES COMPONENT SELECT IN CALIBRATION.
3. ⏚ INDICATES COMMON RETURN.
2. — — — — INDICATES PRINTED CIRCUIT CARD OUTLINE.
1. ▭ INDICATES FRONT PANEL MARKING.

NOTES:

TEST OSCILLATOR
DRAWING NUMBER M810035



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4. △ INDICATES COMPONENT TO BE SELECTED IN CALIBRATION.
3. ▭ INDICATES FRONT PANEL MARKING.
2. ⏚ INDICATES CHASSIS GROUND.
1. ——— INDICATES PRINTED CIRCUIT CARD OUTLINE.

NOTES:

WAVE ANALYZER	
	DRAWING NUMBER M8100-36

SECTION VII

TABLE OF REPLACEABLE PARTS

7-1 This section contains information for ordering replacement parts.

7-2 To obtain replacement parts, address order to:

MICOM, Inc.
855 Commercial Street
Palo Alto, California 94303

Identify parts by means of their reference designation and include the model and serial number of the instrument. For non-listed parts include model and serial number, description of the part, and function and location of the part.

ABBREVIATIONS

A	Arco
AB	Allen Bradley
ANL	Amphenol
B	Bourns
CL	Clarostat
CRL	Centralab
D	Dialco
EL	Electra Manufacturing Company
EM	Electromotive Manufacturing Co.
F	Fairchild
GE	General Electric
GI	General Instrument
IRC	International Resistance Company
KT	Kemet
MO	Motorola
S	Sprague
SC	Switchcraft
SH	Siemens and Halske
SY	Sylvania
TI	Texas Instruments
TRW	Thompson Ramo Woolridge
VK	Viking

Al elect	Aluminum electrolytic
cer	ceramic
comp	composition
fxd	fixed
Ge	Germanium
met flm	metal film
my	mylar
poly	polystyrene
Si	Silicon
sil mica	silver mica
Ta	Tantalum
var	variable
ww	wire wound

M	10^6
K	10^3
D	10
d	10^{-1}
m	10^{-3}
μ	10^{-6}
n	10^{-9}
p	10^{-12}

A	Ampere
dB	deciBel
F	Farad
H	Henry
Hz	cycle per second

Table 7-1. Replaceable Parts

SCHEMATIC REFERENCE	DESCRIPTION OR COMMERCIAL EQUIVALENT	MICOM PART NO.
POWER SUPPLY AND REGULATOR 8100-30 (201-30)		
C1	C: fxd, 300μF, 150V, Al elect	15:79:3018
C2	C: fxd, 500μF, 25V, Al elect	15:76:5018
C3	C: fxd, 35μF, 50V, Al elect	15:78:3508
C4, C5	C: fxd, 150μF, 15V, Al elect	15:74:1518
C6	C: fxd, .01μF, 250V, my	15:29:1037
CR1 thru CR5	diode Si 1N4383	48:12:2013
CR6	diode Si 1N458A	48:12:1006
F1	.5A 3AG Slo-Blo	51:12:0050
XF1	Fuse holder	21:27:1700
J6	p.c. connector 15 pin VK 2VK15S/1-2	21:21:0815
J13 (Prior to 067)	3 pin ac power connector ANL 160-5	21:14:0603
J13	Connector 3 pin ac SC AC-3 Male Power	21:14:1803
Q1, Q2	transistor PNP Ge power 2N376A	48:21:2002
Q3	transistor NPN Ge 2N1302	48:21:1014
Q4	transistor PNP Ge 2N404	48:21:1008
Q5	transistor PNP 6.3V Zener 2N3638	48:62:1003
Q6	transistor NPN Si 2N2925	48:22:1004
Q7, Q8	transistor PNP Si 2N3638	48:22:1003
R1	R: fxd, comp, 100 ohms 10% 2w	47:24:1011
R2	R: fxd, comp, 10 ohms 5% 1/2w	47:22:1005
R3	R: fxd, comp, 200 ohms 5% 1/2w	47:22:2015
R4	R: fxd, comp, 10K 5% 1/2w	47:22:1035
R5, R15, R17	R: fxd, comp, 1K 5% 1/2w	47:22:1025
R6	R: fxd, met flm, 10K 1% 1/2w	47:12:1002
R7	R: fxd, met flm, 2.67K 1% 1/2w	47:12:2671
R8, R13	R: fxd, met flm, 5.11K 1% 1/2w	47:12:5111
R9	R: fxd, comp, 5.6K 5% 1/2w	47:22:5625
R10	R: fxd, comp, 33K 5% 1/2w	47:22:3335
R11	R: fxd, comp, 470 ohms 5% 1/2w	47:22:4715
R12	R: var, ww, 1K B 3067P-1-102	47:52:1021
R14	R: fxd, met flm, 1K 1% 1/2w	47:12:1001
R16, R19	R: fxd, comp, 3.9K 5% 1/2w	47:22:3925
R18	R: fxd, comp, 8.2K 5% 1/2w	47:22:8225
S7	Switch, rocker, DPDT SC 51204L	51:52:0202
S9	Switch, line slide DPDT SC 46256LF	51:22:0201
T1	transformer	56:11:1249
SIGNAL AGC AMPLIFIER 8100-31		
C1	C: fxd, 0.1μF, 250V, my	15:29:1046
C2, C3, C10, C13	C: fxd, 3.3μF, 15V, Ta	15:24:3357
C4	C: fxd, 200pF, 100V, cer	15:19:2016
C5	C: fxd, 0.022μF, 250V, my	15:29:2237
C6, C7, C8	C: fxd, 0.01μF, 250V, my	15:29:1037
C9	C: fxd, 0.27μF, 250V, my	15:29:2746
C11	C: fxd, 22μF, 15V, Ta	15:34:2267
C12	C: fxd, 500pF, 100V cer	15:19:5016
C14	C: fxd, 15μF, 20V, Ta	15:35:1567

Table 7-1. Replaceable Parts (Cont'd.)

SCHEMATIC REFERENCE	DESCRIPTION OR COMMERCIAL EQUIVALENT	MICOM PART NO.
CR1 thru CR4, CR6 thru CR8	diode Si 1N458A	48:12:1006
CR5, CR9	diode Ge 1N90	48:11:1007
DS1	lamp 6V 40mA orange D 39-604-1473	39:13:0640
DS2	lamp 6V 40mA white D 39-604-1475	39:19:0640
J1	p.c. connector 15 pin VK 2VK15S/1-2	21:21:0815
J9	BNC jack UG657/U	21:25:0700
Q1, Q2, Q4, Q5, Q6, Q8, Q9, Q11, Q12	transistor NPN Si 2N2925	48:22:1004
Q3, Q7, Q10	transistor PNP Si 2N3638	48:22:1003
R1, R21	R: fxd, comp, 1K 5% 1/2w	47:22:1025
R2	R: fxd, comp, 270K 5% 1/2w	47:22:2745
R3, R6, R9, R16, R19, R33	R: fxd, comp, 100K 5% 1/2w	47:22:1045
R4, R18	R: fxd, comp, 330K 5% 1/2w	47:22:3345
R5	R: fxd, met flm, 1M 1% 1/2w	47:12:1004
R7, R25	R: fxd, comp, 68K 5% 1/2w	47:22:6835
R8	R: fxd, comp, 47K 5% 1/2w	47:22:4735
R10, R13, R22, R31, R35, R44	R: fxd, comp, 10K 5% 1/2w	47:22:1035
R11, R28	R: fxd, comp, 220K 5% 1/2w	47:22:2245
R12	R: fxd, comp, 6.2K 5% 1/2w	47:22:6225
R14, R26	R: fxd, comp, 15K 5% 1/2w	47:22:1535
R15	R: fxd, comp, 200K 5% 1/2w	47:22:2045
R17	R: fxd, selected	
R20	R: fxd, comp, 39 ohms 5% 1/2w	47:22:3905
R23	R: fxd, comp, 330 ohms 5% 1/2w	47:22:3315
R24	R: fxd, comp, 300 ohms 5% 1/2w	47:22:3015
R27	R: fxd, comp, 6.8K 5% 1/2w	47:22:6825
R29, R38	R: fxd, comp, 3.9K 5% 1/2w	47:22:3925
R30, R37	R: fxd, comp, 27K 5% 1/2w	47:22:2735
R32, R41	R: fxd, comp, 4.7K 5% 1/2w	47:22:4725
R34	R: fxd, comp, 2.2K 5% 1/2w	47:22:2225
R36, R39	R: fxd, comp, 22K 5% 1/2w	47:22:2235
R40, R43	R: fxd, comp, 3.3K 5% 1/2w	47:22:3325
R42, R45	R: fxd, comp, 150 ohms 5% 1/2w	47:22:1515
S1	Switch, Assembly, MICOM 51:74:0509	51:74:0509
LIMITER, QUANTUM CHARGE GENERATOR, DEMODULATOR 8100-32		
C1	C: fxd, 0.22μF, 250V, my	15:29:2246
C2	C: fxd, 500pF, 100V, cer	15:19:5016
C3	C: fxd, 200pF, 100V, cer	15:19:2016
C4	C: fxd, 25μF, 25V, Al elect	15:76:3508
C5	C: fxd, 1000pF, 100V, cer	15:19:1026
C6, C12	C: fxd, 0.1μF, 250V my	15:29:1046
C7	C: fxd, 500μF, 3V, Al elect	15:71:5018
C8	C: fxd, 3600pF 5% sil mica	15:49:3625
C9	C: fxd, 3900pF 5% sil mica	15:49:3925
C10	C: selected mica	
C11	C: var, 8-50pF ceramic trimmer Erie 557-013V2PO 34R	15:59:500X
C13	C: fxd, 15μF, 20V, Ta	15:35:1567
C14, C15	C: fxd, 0.022μF, 250V, my	15:29:2237

Table 7-1. Replaceable Parts (Cont'd.)

SCHEMATIC REFERENCE	DESCRIPTION OR COMMERCIAL EQUIVALENT	MICOM PART NO.
CR1, CR4 thru CR8	diode Si 1N458A	48:12:1006
CR2, CR3	diode Ge 1N90	48:11:1007
CR9	diode Si high speed 1N3064	48:12:1005
J4	p.c. connector 15 pin VK 2VK15S/1-2	21:21:0815
Q1 thru Q3	transistor PNP Ge 2N404	48:21:1008
Q4, Q5	transistor NPN Ge 2N1302	48:21:1014
Q6	transistor PNP Ge 2N398	48:21:1012
Q7	transistor PNP Ge 2N1065	48:21:1001
Q8	transistor NPN Si 2N2925	48:22:1004
R1 thru R11, R13	R: fxd, met flm, 1K 1% 1/2w	47:12:1001
R12	R: var, 2.7K comp	47:94:273 Sp.
R14	R: fxd, comp, 51K 5% 1/2w	47:22:5135
R15	R: fxd, comp, 150K 5% 1/2w In Assembly 51:72:1105	47:22:1545
R16	R: fxd, comp, 56K 5% 1/2w	47:22:5635
R17	R: fxd, comp, 130K 5% 1/2w	47:22:1345
R18	R: fxd, comp, 91K 5% 1/2w	47:22:9135
R19, R26	R: fxd, comp, 15K 5% 1/2w	47:22:1535
R20, R23	R: fxd, comp, 4.7K 5% 1/2w	47:22:4725
R21, R24, R25, R34	R: fxd, comp, 10K 5% 1/2w	47:22:1035
R22	R: fxd, comp, 3.9K 5% 1/2w	47:22:3925
R27	R: fxd, comp, 22K 5% 1/2w	47:22:2235
R28	R: fxd, comp, 6.8K 5% 1/2w	47:22:6825
R29	R: fxd, comp, 33K 5% 1/2w	47:22:3335
R30, R31, R39	R: fxd, comp, 2.2K 5% 1/2w	47:22:2225
R32	R: fxd, comp, 470 ohms 5% 1/2w	47:22:4715
R33, R36	R: fxd, comp, 1.5K 5% 1/2w	47:22:1525
R35	R: fxd, comp, 680 ohms 5% 1/2w	47:22:6815
R37	R: fxd, comp, 47K 5% 1/2w	47:22:4735
R38	R: fxd, met flm, 5.76K 1% 1/2w	47:12:5761
R40, R45, R46	R: fxd, met flm, 10K 1% 1/2w	47:12:1002
R41	R: fxd, met flm, 1.5K 1% 1/2w	47:12:1501
R42	R: fxd, ww, 45.00K 0.1%	47:32:4502
R43	R: fxd, comp, 47 ohms 5% 1/2w	47:22:4705
R44	R: fxd, comp, 100 ohms 5% 1/2w	47:22:1015
S2	Switch, Assembly: Zero Set MICOM 51:72:1105	51:72:1105
DRIFT AMPLIFIER 8100-33		
C1, C2	C: fxd, 6.8μF, 35V, Ta	15:37:6857
C3, C5	C: fxd, 300pF, 100V, cer	15:19:3016
C4, C10	C: fxd, 0.01μF, 250V, my	15:29:1037
C6, C13	C: fxd, 0.1μF, 250V, my	15:29:1046
C7	C: fxd, 0.022μF, 250V, my	15:29:2237
C8, C9	C: fxd, 5.6μF, 35V, Ta	15:37:5657
C11, C12	C: fxd, 56μF, 6V, Ta	15:32:5667
C14, C15	C: fxd, 2.2μF, 20V, Ta	15:35:2257
CR1 thru CR5	diode Si 1N458A	48:12:1006
DS3	lamp 6V 40mA orange D 39-604-1473	39:13:0640
J2	p.c. connector 15 pin VK 2VK15S/1-2	21:21:0815
J10	BNC jack UG657/U	21:25:0700
M1	50-0-50μA meter	29:31:2003

Table 7-1. Replaceable Parts (Cont'd.)

SCHEMATIC REFERENCE	DESCRIPTION OR COMMERCIAL EQUIVALENT		MICOM PART NO.
Q1, Q2	transistor NPN Si 2N2925, matched pair		48:22:1021
Q3, Q4, Q10, Q11	transistor NPN Si 2N2925		48:22:1004
Q5 thru Q9	transistor PNP Si 2N3638		48:22:1003
R1	R: fxd, met flm, 71.5 ohms 1% 1/2w		47:12:715A
R2	R: fxd, met flm, 237 ohms 1% 1/2w		47:12:2370
R3	R: fxd, met flm, 715 ohms 1% 1/2w	Part of 51:71:0601	47:12:7150
R4	R: fxd, met flm, 2.61K 1% 1/2w		47:12:2611
R5	R: fxd, met flm, 10.2K 1% 1/2w		47:12:1022
R6	R: fxd, met flm, 12.7K 1% 1/2w		47:12:1272
R7, R9	R: fxd, comp, 3.9M 5% 1/2w		47:22:3955
R8	R: fxd, comp, 620K 5% 1/2w		47:22:6245
R10, R14	R: fxd, comp, 200K 5% 1/2w		47:22:2045
R11, R27, R36	R: fxd, comp, 10K 5% 1/2w		47:22:1035
R12	R: fxd, comp, 20 ohms 5% 1/2w		47:22:2005
R13	R: fxd, comp, 120K 5% 1/2w		47:22:1245
R15	R: selected		
R16, R21	R: fxd, comp, 1.5K 5% 1/2w		47:22:1525
R17, R22	R: fxd, comp, 100K 5% 1/2w		47:22:1045
R18, R20, R38, R40, R42	R: fxd, comp, 4.7K 5% 1/2w		47:22:4725
R19	R: fxd, comp, 6.2K 5% 1/2w		47:22:6225
R23	R: fxd, comp, 22K 5% 1/2w		47:22:2235
R24	R: fxd, comp, 100 ohms 5% 1/2w		47:22:1015
R25, R26	R: fxd, met flm, 47.5K 1% 1/2w		47:12:4752
R28	R: fxd, met flm, 60.4K 1% 1/2w		47:12:6042
R29	R: fxd, met flm, 59K 1% 1/2w		47:12:5902
R30	R: fxd, met flm, 30.1K 1% 1/2w		47:12:3012
R31	R: fxd, met flm, 28.7K 1% 1/2w		47:12:2872
R32	R: fxd, met flm, 1K 1% 1/2w		47:12:1001
R33	R: fxd, comp, 330K 5% 1/2w		47:22:3345
R34	R: fxd, comp, 68K 5% 1/2w		47:22:6835
R35	R: fxd, comp, 3.9K 5% 1/2w		47:22:3925
R37	R: fxd, comp, 30K 5% 1/2w		47:22:3035
R39	R: fxd, comp, 6.8K 5% 1/2w		47:22:6825
R41	R: fxd, comp, 150 ohms 5% 1/2w		47:22:1515
S3	Switch, Assembly, MICOM 51:71:0601		51:71:0601
S8	Switch, 3 pol 3 pos slide SC 49329LŠ		51:24:0313
FLUTTER AMPLIFIER AND METER DRIVER 8100-34			
C1	C: fxd, 120μF, 10V, Ta		15:33:1277
C2, C15	C: selected		
C3	C: fxd, 2.2μF, 20V, Ta		15:35:2257
C4	C: fxd, 6.8μF, 35V, Ta		15:37:6857
C5	C: fxd, 3.3μF 15V, Ta		15:34:3357
C6	C: fxd, 10μF, 20V, Ta		15:35:1067
C7	C: fxd, 15μF, 20V, Ta		15:35:1567
C8	C: fxd, 8.2μF, 20V, Ta		15:35:8257
C9	C: fxd, 0.47μF, 250V, my		15:29:4746
C10	C: fxd, 0.47μF, 35V Ta		15:37:4747
C11, C13, C17	C: fxd, 0.022μF, 250V, my		15:29:2237
C12	C: fxd, 330μF, 6V, Ta		15:32:3377
C14	C: fxd, 100pF, 100V, cer		15:19:1016
C16	C: fxd, 2700pF, 100V, cer		15:19:2726
C18	C: fxd, 2000pF, 100V, cer		15:19:2026
CR1 thru CR9	diode Si 1N458A		48:12:1006

Table 7-1. Replaceable Parts (Cont'd.)

SCHEMATIC REFERENCE	DESCRIPTION OR COMMERCIAL EQUIVALENT	MICOM PART NO.
J3	p.c. connector 15 pin VK 2VK15S/1-2	21:21:0815
J11, J12	BNC jacks UG657/U	21:25:0700
M2	0-200 μA meter V.U. dynamics	29:31:1004
Q1, Q2, Q8	transistor NPN Si 2N2925	48:22:1004
Q3 thru Q5	transistor PNP Si 2N3638	48:22:1003
Q9 thru Q11		
Q6, Q7	transistor NPN Si 2N2925, matched pair	48:22:1021
R1	R: fxd, met flm, 4.99K 1% 1/2w	47:12:4991
R2	R: fxd, met flm, 1.62K 1% 1/2w	47:12:1621
R3	R: fxd, met flm, 681 ohms 1% 1/2w	47:12:6810
R4	R: fxd, met flm, 17.8K 1% 1/2w	47:12:1782
R5	R: fxd, met flm, 1.4K 1% 1/2w	47:12:1401
R6	R: fxd, met flm, 4.75K 1% 1/2w	47:12:4751
R7	R: fxd, met flm, 21.5K 1% 1/2w	47:12:2152
R8	R: fxd, comp, 10M 5% 1/2w	47:22:1065
R9, R10, R13 thru R15, R28	R: selected	
R11	R: fxd, comp, 560 ohms 5% 1/2w	47:22:5615
R12	R: fxd, met flm, 30.1K 1% 1/2w	47:12:3012
R16	R: fxd, comp, 3.3K 5% 1/2w	47:22:3325
R17, R26, R35, R40, R48, R50	R: fxd, comp, 100K 5% 1/2w	47:22:1045
R18	R: fxd, comp, 620 ohms 5% 1/2w	47:22:6215
R19, R41	R: fxd, comp, 2.7M 5% 1/2w	47:22:2755
R20	R: fxd, met flm, 1M 1% 1/2w	47:12:1004
R21	R: fxd, met flm, 20K 1% 1/2w	47:12:2002
R22	R: fxd, comp, 22K 5% 1/2w	47:22:2235
R23	R: fxd, comp, 1.2M 5% 1/2w	47:22:1255
R24	R: fxd, comp, 390K 5% 1/2w	47:22:3945
R25	R: fxd, comp, 270K 5% 1/2w	47:22:2745
R27, R31, R32, R38, R46	R: fxd, comp, 33K 5% 1/2w	47:22:3335
R29	R: fxd, comp, 1K 5% 1/2w	47:22:1025
R30, R56	R: fxd, comp, 47K 5% 1/2w	47:22:4735
R33	R: fxd, comp, 430K 5% 1/2w	47:22:4345
R34	R: fxd, comp, 330K 5% 1/2w	47:22:3345
R36	R: fxd, comp, 68K 5% 1/2w	47:22:6835
R37	R: fxd, met flm, 100K 1% 1/2w	47:12:1003
R39	R: fxd, met flm, 69.8K 1% 1/2w	47:12:6982
R42, R47	R: fxd, met flm, 681K 1% 1/2w	47:12:6813
R43	R: fxd, comp, 470K 5% 1/2w	47:22:4745
R44	R: fxd, comp, 1.5M 5% 1/2w	47:22:1555
R45, R57	R: fxd, comp, 10K 5% 1/2w	47:22:1035
R49	R: fxd, comp, 220K 5% 1/2w	47:22:2245
R51	R: fxd, comp, 1.5K 5% 1/2w	47:22:1525
R52	R: fxd, comp, 8.2K 5% 1/2w	47:22:8225
R53	R: fxd, comp, 6.8K 5% 1/2w	47:22:6825
R54	R: fxd, comp, 100 ohms 5% 1/2w	47:22:1015
R55	R: fxd, comp, 180K 5% 1/2w	47:22:1845
S4	Switch, % Flutter Assembly, MICOM 51:72:0703	51:72:0703
S5	Switch, WTD Assembly	51:74:0414
S6	Switch, 2 pol 5 pos (8100) CRL PA1002	51:42:0512
	METER SELECT Assembly (8100-W)	51:74:0507

Table 7-1. Replaceable Parts (Cont'd.)

SCHEMATIC REFERENCE	DESCRIPTION OR COMMERCIAL EQUIVALENT	MICOM PART NO.
TEST OSCILLATOR 8100-35		
C1	C: fxd, 1.0μF, 250V, my	15:29:1056
C2, C3	C: fxd, 22μF, 15V, Ta	15:34:2267
C4	C: fxd, 3000pF, 500V, poly	15:89:3025
C5, C6	C: fxd, 0.033μF, 100V, poly	15:89:3335
C7	C: fxd, selected, mica	
C8, C9	C: fxd, selected, if used	
C10	C: var. 8-50pF ceramic trimmer, Erie 587-013 U2PO-34R	15:59:500X
DS1	lamp 10V 15mA SY 10CS/B1031	39:4X:1015
J5	p.c. connector 15 pin VK 2VK15S/1-2	21:21:0815
J8	BNC jack UG657/U	21:25:0700
L1	inductor 1 Hy tapped toroid	18:14:1055
Q1, Q4	transistor PNP Si 2N3638	48:22:1003
Q2, Q3	transistor NPN Si 2N2925	48:22:1004
R1	R: fxd, comp, 62 ohms 5% 1/2w	47:22:6205
R2	R: fxd, comp, 100K 5% 1/2w	47:22:1045
R3, R4, R13	R: fxd, comp, 470 ohms 5% 1/2w	47:22:4715
R5	R: fxd, comp, 150 ohms 5% 1/2w	47:22:1515
R6	R: fxd, comp, 2.2K 5% 1/2w	47:22:2225
R7	R: fxd, comp, 820 ohms 5% 1/2w	47:22:8215
R8	R: fxd, comp, 330 ohms 5% 1/2w	47:22:3315
R9	R: fxd, comp, 3K 5% 1/2w	47:22:3025
R10	R: var, ww, 2K B 3067P-1-202	47:52:2021
R11	R: fxd, comp, 1K 5% 1/2w	47:22:1025
R12	R: fxd, comp, 10K 5% 1/2w	47:22:1035
R14	R: fxd, comp, 91K 5% 1/2w selected	47:22:9135
R15	R: fxd, comp, 47K 5% 1/2w	47:22:4735
WAVE ANALYZER 8100-36		
C1, C6	C: fxd, 0.016μF, 250V, my	15:29:1631
C2, C7	C: fxd, 0.16μF, 250V, my	15:29:1641
C3, C8	C: fxd, 1.6μF, 250V, my	15:29:1651
C4	C: fxd, 500pF, 100V, cer	15:19:5016
C5	C: fxd, 4700pF, 100V, cer	15:19:4726
C9	C: fxd, 200pF, 100V, cer	15:19:2016
CR1	diode Si 1N458A	48:12:1006
J7	p.c. connector 15 pin VK 2VK15S/1-2	21:21:0815
J12	BNC jack UG657/U	21:25:0700
Q1, Q4, Q5, Q7, Q8	transistor NPN Si 2N2925	48:22:1004
Q2, Q3, Q6	transistor PNP Si 2N3638	48:22:1003
R1	R: var, dual ww 10K spec.	47:9A:103A
R2, R3, R5, R21, R28	R: selected	
R4	R: fxd, comp, 200K 5% 1/2w	47:22:2045
R6, R22, R24	R: fxd, comp, 820 ohms 5% 1/2w	47:22:8215
R7, R10, R23	R: fxd, comp, 470K 5% 1/2w	47:22:4745
R8	R: fxd, met flm, 825 ohms 1%, 1/2w	47:12:8250

Table 7-1. Replaceable Parts (Cont'd.)

SCHEMATIC REFERENCE	DESCRIPTION OR COMMERCIAL EQUIVALENT	MICOM PART NO.
R9	R: fxd, comp, 22K 5% 1/2w	47:22:2235
R11, R26	R: fxd, comp, 470 ohms 5% 1/2w	47:22:4715
R12, R31	R: fxd, met flm, 20K 1% 1/2w	47:12:2002
R13	R: fxd, comp, 6.2K 5% 1/2w	47:22:6225
R14, R15, R34	R: fxd, comp, 33K 5% 1/2w	47:22:3335
R16, R35	R: fxd, comp, 10K 5% 1/2w	47:22:1035
R17, R27	R: fxd, comp, 330 ohms 5% 1/2w	47:22:3315
R18, R19	R: fxd, met flm, 2.55K 1% 1/2w	47:12:2551
R20, R29	R: fxd, comp, 22K 5% 1/2w	47:22:2235
R25	R: var, ww, 1K CL 439-1000	47:54:1021
R30	R: fxd, comp, 120K 5% 1/2w	47:22:1245
R32	R: fxd, comp, 12K 5% 1/2w	47:22:1235
R33	R: fxd, comp, 4.7K 5% 1/2w	47:22:4725
S6	Switch, METER SELECT Assembly	51:74:0507

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